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THE PATHOLOGY OF CHRONIC CYSTIC MASTITIS OF THE FEMALE BREAST

WITH SPECIAL CONSIDERATION OF THE BLUE-DOMED CYST *

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* Figures 1 to 29 and 32 to 91 from photographs made by Mr. Herman Schapiro; Figures 30 and 31 from paintings by Miss Susie Hayes.

This paper will describe chiefly the pathology of the various types of chronic cystic mastitis as exposed by an exploratory incision. The more detailed clinical and other studies are reserved for a second paper.

CLASSIFICATION OF CHRONIC CYSTIC MASTITIS

For the present, I have subdivided this lesion of the breast into the following types, giving my abbreviations and nomenclature for each type:

BB-12-1,-2,-3: Single or multiple cysts in chronic cystic mastitis, 210 cases.

BB-13-4,-5,-6,-7,-8: Chronic cystic mastitis without large cysts, 140 cases.

BB-12-1: The blue-domed cyst, 174 cases.

BB-12-2: The cyst of the galactocele type, 8 cases.

BB-12-3: The multiple blue-domed cysts in one or both breasts (diffuse cystic disease of the breast), 28 cases.

BB-13-4: The nonencapsulated adenomatous area, 48 cases.

BB-13-5: The nonencapsulated area of chronic cystic mastitis, containing one or more minute cysts, or one or more dilated ducts, or both, 39 cases.

BB-13-6: The diffuse dilatation of the ducts, chiefly in the nipple zone, rarely in the breast outside this zone, 22 cases.

BB-13-7: The nonencapsulated cystic adenoma, 18 cases.

BB-13-8: The diffuse nonencapsulated cystic adenoma, known in the literature as Schimmelbusch's or Réclus' disease, or senile parenchymatous hypertrophy (Bloodgood), 13 cases.

PATHOLOGY IN BRIEF

BB-12-1. The Blue-Domed Cyst.—For the gross appearance, see Figures 1 to 8; for the microscopic appearance see Figures 37, 38, 45, 46, 47, 52, 55, 59 and 73.

The characteristic gross feature is a distinct blue dome (Figs. 1 and 2). This can be recognized if, when cutting down over the tumor, one proceeds slowly, checks hemorrhage, and from time to time moves the knife from side to side. The blue dome in the majority of cases is exposed after dividing the subcutaneous fat. In a certain percentage of cases, the cyst is buried in breast tissue, and one must divide a zone of breast before exposing the cyst. Very rarely is the cyst situated behind the breast on the pectoral fascia (Fig. 4).

When the cyst wall is nicked, its color immediately disappears. The cyst wall is, as a rule, thin (1 mm.); in less than 10 per cent. of the cases it has been thicker (2 to 3 mm.). The contents of the cyst have never been hemorrhagic—they are either clear or cloudy; in four cases (all from outside surgeons) they have been noted as "brown." In all of my own cases, they have been clear or cloudy. The inner wall of the cyst is smooth, without papilloma, and there may be partial partitions or septums.

B B-12-2. The Cyst of the Galactocele Type.—For the gross appearance, see Figures 9 and 10; for the microscopic appearance, see Figure 44.

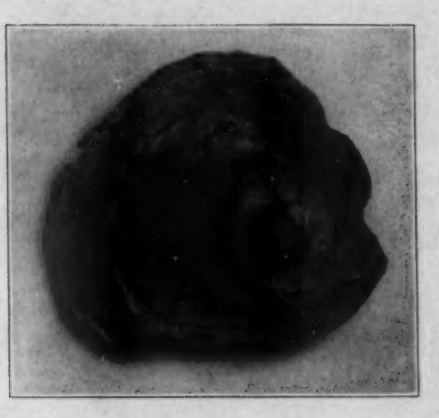

Fig. 1 (Path. No. 25508. BB-12-1 [T]).—Blue-domed cyst, unopened, projecting from the surrounding breast; excised zone of breast, adenomatous. Result (1921): Well, six months after incision of cyst with zone of breast. See page 469.

In this and the following legends the abbreviations for operative procedures are: [T] excision of tumor and zone of breast only; [B] excision of one breast without exploratory incision; [BB] excision of both breasts without exploratory incision; [CC] complete operation for cancer without exploratory incision, and [Expl.] exploratory incision.

Fig. 2 (Path. No. 27762. BB-12-1 [T]).—Blue-domed cyst, unopened, projecting from zone of breast. See Figure 3 for cross-section; also see page 470.

This type is less frequent than the blue-domed cyst—as 8 cases are to 174, and differs from the blue-domed cyst in that, when its dome is exposed, it is white or gray. As a rule, the wall is a little thicker. The contents not only resemble milk in appearance, but also are coagulated by liquor formaldehydi, while the contents of the blue-domed cyst are not.

BB-12-3. Multiple Cysts in One or Both Breasts (Diffuse Cystic Disease of the Breast).—For the gross appearance, see Figures 11 and 12; for the microscopic appearance, see Figures 36, 43, 48 and 62.

The cysts are of the blue-domed type; a few may be of the galactocele type. The breast, or breasts, are riddled with cysts of various sizes. The character of the wall and the contents are identical with those of the blue-domed cyst or the cyst of the galactocele type. The frequency of this multiple cystic disease of the breast is as 28 to 210, or about 13 per cent.

Fig. 3 (Path. No. 27762. BB-12-1 [T]).—Section through blue-domed cyst and zone of breast excised, shown in Figure 2: *C*, minute blue-domed cyst; *Ad*, adenomatous area; *S*, fibrous stroma; *F*, fat. Result (1921): Well, four months after excision of cyst with zone of breast. See page 471.

BB-13-4. The Nonencapsulated Adenomatous Area.—For the gross appearance, see Figures 13 and 14; for the microscopic appearance, see Figures 35 and 69.

When this type occurs clinically as a single definite tumor, one must explore to exclude a malignant lesion. Then the palpable tumor will appear as a nonencapsulated area of breast tissue, in which the elevated pink and gray dots representing the adenomatous lobules are more numerous than in the surrounding breast. This area resembles somewhat the fibro-adenoma, but has less stroma. When this type presents itself clinically, as multiple, somewhat indefinite, nodules in one or both breasts, each nodule is practically identical in the gross

and microscopic picture. I am inclined to the conclusion that, when multiple, the disease corresponds to that described by Warren, of Boston, as the *cobble-stone breast,* and my recent experience teaches me that operation is *not* indicated when one can make out multiple, indefinite nodules in both breasts. However, when there is a single definite tumor, it must be explored.

BB-13-5. Nonencapsulated Area of Chronic Cystic Mastitis Containing One or More Minute Cysts, or One or More Dilated Ducts, or Both.—For the gross appearance, see Figure 15; for the microscopic appearance, see Figures 32, 63, 67 and 68.

Fig. 4 (Path. No. 25560. BB-12-1 [CC]).—Blue-domed cyst surrounded by fatty senile breast. Result (1921): Well, eighteen months after complete operation for cancer. See page 471.

When this type appears clinically as a single tumor, it must be explored. It differs in the gross from the nonencapsulated adenomatous area (BB-13-4, Figs. 13 and 14) only in the presence of one or more minute cysts, or one or more dilated ducts. If the latter are present, there is liable to be mastitis (Figs. 15, 63 and 67).

This type may also occur clinically as multiple indefinite nodules, and corresponds to Warren's cobble-stone breast. Operation is not indicated, unless there is a single definite tumor which must be explored.

It is important to note here that among 140 cases of chronic cystic mastitis of the types BB-13 (-4,-5,-6,-7 and -8) eighty-seven, more than 50 per cent., belong to the groups BB-13 (-4-5) and in many of these cases the clinical picture was that of the cobble-stone breast of Warren, in which operation is not indicated. In this group BB-13 (-4-5) in which there are eighty-seven cases, many breasts were unnecessarily sacrificed because of the fear of cancer, inability to make a correct clinical diagnosis, or to interpret the gross and microscopic picture at the exploratory incision.

BB-13-6. Diffuse Dilatation of the Ducts Chiefly in the Nipple Zone, Rarely in the Breast Outside This Zone.—For the gross appearance, see Figures 16 to 20; for the microscopic appearance, see Figures 49, 50, 51, 65, 66 and 78.

Fig. 5 (Path. No. 10940. BB-12-1 [T]).—Section through blue-domed cyst and zone of excised surrounding breast. Note thin, smooth wall of large cyst; surrounding breast adenomatous; a few dilated ducts (*DD*) which contained creamlike material; also much stroma and fat. Result (1921): Well, eleven years after excision of cyst with zone of breast. See page 473.

The characteristic clinical picture when the dilated ducts are situated in the nipple zone is the palpation of a doughy, wormlike mass beneath the nipple. When explored, one can recognize large and small dilated ducts with distinct walls containing brown, green, milky or creamlike material, of various degrees of viscosity and consistency. The contents when expressed appeared as soft, wormlike masses, exposing the distinct, smooth wall of the duct—a gross picture, if carefully inspected, different from that of the comedo-adenoma.

When it occurs in a zone of breast outside the nipple area (Fig. 19), it feels like diffuse mastitis, but has not the distinct edge or border of BB-13 (-8) the diffuse nonencapsulated cystic adenoma.

My recent experience indicates that when one can diagnose this lesion by palpating the wormlike tumor beneath one or both nipples, operation is not indicated.

BB-13-7. Nonencapsulated Cystic Adenoma.—For the gross appearance, see Figures 21 and 22; for the microscopic appearance, see Figures 53, 58, 60, 64, 70, 71, 72, 74, 75, 77, 79, 80, 81, 82, 86, 87, 90 and 91.

Fig. 6 (Path. No. 27007. BB-12-1 [T]).—Section through a large blue-domed cyst and surrounding breast, showing the small dark areas in the wall of the large cyst. These are due to minute areas of hemorrhage (Fig. 46). The surrounding breast shows one minute cyst, one dilated duct without contents, and a few adenomatous areas. The breast consists chiefly of fibrous stroma and fat. Result (1921): Well, eight months after excision of cyst with zone of breast. See page 476.

This tumor, in the gross, does not differ from BB-16, the *encapsulated* cystic adenoma. We have twenty-two examples of the encapsulated cystic adenoma, and eighteen of the *nonencapsulated*.

After most careful restudy of all the gross and microscopic specimens, I can see practically no difference between the two lesions, except the absence of a capsule in the *nonencapsulated* cystic adenoma, the presence of a little more fibrous tissue, and (one example) the presence of scirrhous carcinoma, in combination with the nonencapsulated cystic adenoma (Figs. 86 and 87).

In the twenty-two cases of encapsulated cystic adenoma, the surgeons removed the tumor only. When sections are submitted to many pathologists, the diagnosis of *adenocarcinoma* is frequently made. But there has been no recurrence in any of these twenty-two cases, notwithstanding the fact that only the tumor had been removed.

Fig. 7 (Path. No. 21770. BB-12-1 [T]).—Blue-domed cyst, unopened, and zone of surrounding breast. See Figure 8 and page 479.

In contrast, all the eighteen cases of BB-13-7, the nonencapsulated cystic adenoma, except one, have ultimately been subjected to the complete operation for cancer. None showed metastasis to the axillary glands; in none has there been recurrence or death from cancer.

BB-13-8. Diffuse, Nonencapsulated Cystic Adenoma (Known in the Literature as Schimmelbusch's or Réclus' Disease).—For the gross appearance, see Figures 23 to 29; for the clinical picture when associ-

ated with retracted nipples, see Figure 29; for the microscopic appearance, see Figures 39, 40, 41, 42, 54, 56, 57, 61, 76, 83, 84, 85, 88 and 89.

The characteristic clinical picture in these thirteen cases is the palpation of a zone of mastitis in which one can feel many small, shotlike masses. The edge of the involved breast is distinctly palpable. The disease may involve a quadrant, a hemisphere or both breasts. In a few cases, it is associated with intermittent retraction of the nipple; and if operation is delayed, the retraction becomes permanent (Fig. 29).

The clinical picture is so distinct and characteristic that one need not explore. The gross appearance and the microscopic picture are identical with the encapsulated and the nonencapsulated cystic adenoma (BB-13-7).

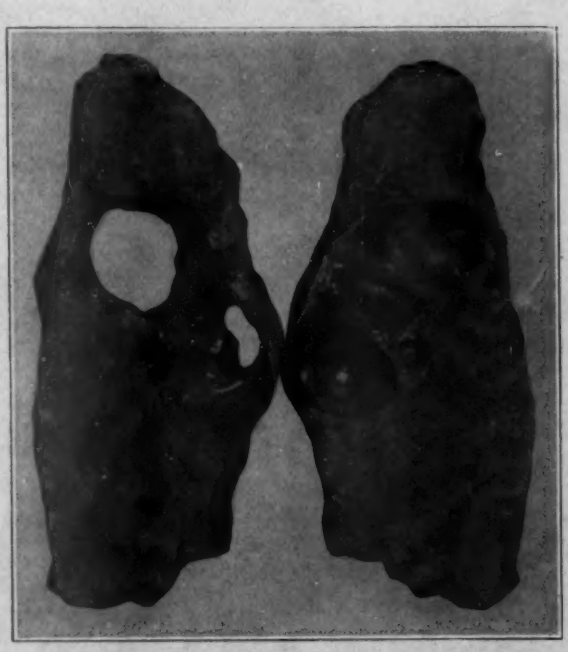

Fig. 8 (Path. No. 21770. BB-12-1 [T]).—Section through blue-domed cyst shown unopened in Figure 7, and second, small, cyst. In the surrounding breast there are a few minute cysts and a few dilated ducts; contents of the latter, grayish-brown, pastil material; also marked increase of adenomatous areas; very little fat. For microscopic area, see Figures 47 and 55. Result (1921): Well, five years after excision of cyst with zone of breast. See page 479.

In one of the thirteen cases there was a gross and microscopic area of cancer (Figs. 88 and 89). In this instance the clinical and gross picture was malignant (Fig. 28), and the patient died of metastasis after the complete operation for cancer. The incidence of malignancy is therefore less than 10 per cent.

PATHOLOGY OF THE BREAST SURROUNDING THE VARIOUS TYPES OF CHRONIC CYSTIC MASTITIS

(BB-12-1,-2,-3 and BB-13-4,-5,-6,-7 and -8)

There is nothing in the gross or microscopic pathology of the breast surrounding these different types of palpable tumors which would allow one to distinguish the types of the tumor which lead to operation. These breasts, as a rule, show some evidence of chronic cystic mastitis in the presence of increased adenomatous areas, minute cysts and dilated ducts. The remaining breast tissue now and then is *senile*. The blue-domed cyst, BB-12-1, and the diffuse dilatation of the ducts beneath the nipple, BB-13-6, have been observed in the senile breast more frequently than any other type.

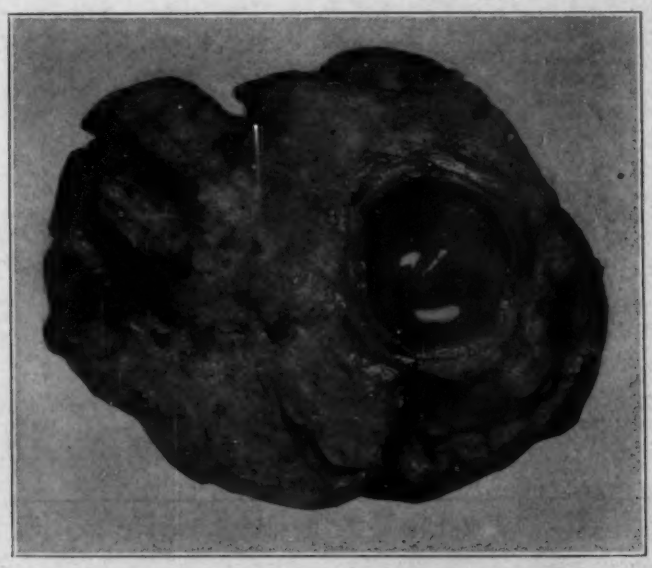

Fig. 9 (Path. No. 26803. BB-12-2 [T]).—Section through white-domed cyst of the galactocele type. The milklike contents of the cyst have coagulated. The surrounding breast is chiefly fibrous stroma mixed with fat, a few adenomatous areas and a few dilated ducts without contents. Specimen sent by Dr. Butt of Davis, W. Va. Result (1921): Well, nine months after excision of cyst and zone of breast. See page 482.

When one cuts out the blue-domed cyst or the cyst of the galactocele type, or one or more of the multiple blue-domed cysts, or the nonencapsulated adenoma, or the nonencapsulated adenoma with cysts or dilated ducts, or the diffuse dilatation of the ducts, or the nonencapsulated cystic adenoma, or the diffuse nonencapsulated cystic adenoma, one may see almost normal breast on the one hand, or senile breast on the other; or the breast may simply show increased adenoma-

tous areas similar to BB-13-4, or minute cysts and dilated ducts, similar to BB-13-5. If the lesion is situated near the nipple, one may expose diffuse dilatation of the ducts almost as pronounced as in BB-13-6.

The relative proportion of the various changes in the breast has no practical significance, nor is it of itself an indication for the removal of the breast. In every type, a zone has been removed, and among these cases, every possible type of chronic cystic mastitis, *except BB-13-8,* has been cut through in removing the palpable tumor, and the results have demonstrated no difference.

This is a very important observation, because many surgeons, when not influenced to remove the breast by the exposed palpable tumor, have been influenced to remove the breast because of the appearance of the surrounding breast tissue. My conclusions are that chronic cystic mastitis is not a lesion of the breast which at the present may

Fig. 10 (Path. No. 25517. BB-12-2 [T]).—Section through white-domed cyst buried in breast tissue. The contents of the cyst consisting of milk-like material, were removed at operation. The surrounding breast shows mastitis (irregular, opaque-white areas), a minute cyst, adenomatous areas, no fat. For microscopic picture, see Figure 44. Result (1921): Well, three years after excision of the cyst and zone of breast. See page 484.

be considered *precancerous,* and its presence does not demand either the complete excision of the breast, or the complete operation for cancer.

For the present, in BB-13-7 and -8 the isolated and diffuse non-encapsulated cystic adenoma, it may be safer completely to remove the breast, or to perform the complete operation for cancer because of the incidence of cancer in two out of 31 cases, less than 10 per cent.

Cancer in the Surrounding Breast.—One of my colleagues, in discussing my paper in New Orleans before the Section on Surgery of the American Medical Association, expressed the opinion that one must have the entire breast in order to exclude cancer. If this were true,

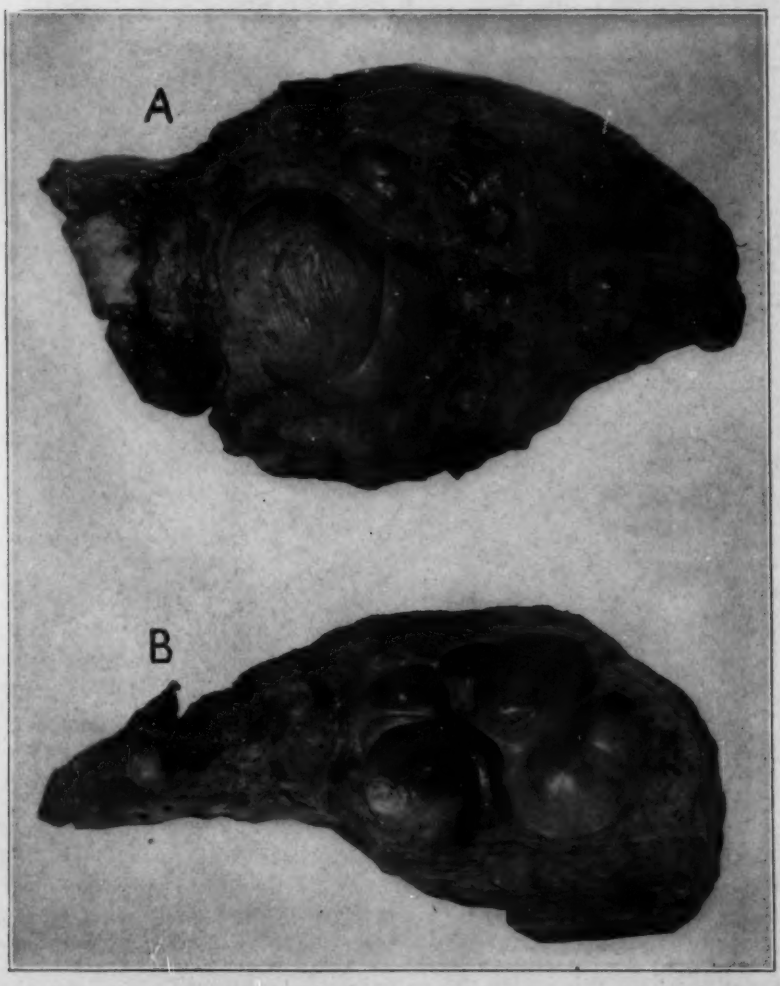

Fig. 11 (Path. No. 26139. BB-12-3 [BB]).—Section through entire breast showing multiple large and small blue-domed cysts—the typical cystic disease of the breast. Specimen sent by Dr. Royster of Raleigh, N. C. Result (1921): Well, eleven months after removal of both breasts. See page 487.

there could be no conservative treatment of benign breast lesions, and there would be no stimulation for differential diagnosis.

The results of my investigation are as follows: Among the 350 cases of chronic cystic mastitis of the various types here described,

we have had an opportunity to study the entire breast in 222 cases in which it was removed. In not a single instance have we found *gross* or *microscopic cancer.* The same is true of about 600 benign breast

Fig. 12 (Path. No. 4903. BB-12-3 [B]).—Section through breast, showing multiple small and large cysts of the blue-domed type, a few empty dilated ducts and a few dilated ducts with granular contents. This is the typical cystic disease of the breast. The breast was excised in Johns Hopkins Hospital in 1903. Result (1921): Well, eighteen years after removal of the breast. The multiple tumors in the remaining breast have disappeared. See page 488.

lesions other than those discussed here. Many of these breasts were unnecessarily removed, thus allowing complete study of the breast tissue.

Among the 350 cases recorded here as chronic cystic mastitis, I mentioned two—*the only two*—in which the microscope revealed positive cancer. One of these was an example of BB-13-8, diffuse nonencapsulated cystic adenoma (Figs. 28 and 88) and was clinically malignant, and the area of cancer was picked out *in the gross*. In the other case, BB-13-7, the area of cancer was recognized in the nonencapsulated cystic adenoma at the exploratory incision.

Therefore, as far as my experience goes with more than 900 benign breast lesions, I have no evidence that one needs more than the palpable tumor, exposed at operation, to make the differential diagnosis.

Of course, if one starts to excise what appears to be a benign tumor and finds in cutting through the surrounding breast tissue an area of cancer, one would immediately proceed with the complete operation for cancer. Up to the present, I have never had such an experience.

Fig. 13 (Path. No. 26695. BB-13-4 [T]).—Section through a zone of breast containing a nonencapsulated area of the fibro-adenomatous type. The nonencapsulated tumor is to the right; the fibrous and fatty breast to the left; there are no cysts or dilated ducts. For microscopic picture, see Figures 35 and 38. Result (1921): Well, nine months after excision of zone of breast shown in illustration. See page 491.

Among about 1,200 cases of *cancer* of the breast, we have either recognized the case clinically as malignant and performed the complete operation without exploratory operation, or, when it has been necessary to explore and we have recognized the malignancy of the tumor, the surrounding breast has not been helpful in the differential diagnosis.

Incidence of Cancer in Chronic Cystic Mastitis.—First, we must consider how frequently cancer has developed when we have removed only the tumor and left the breast. This has happened on only three occasions among 128 cases.

The development of cancer in the breast after the removal of a zone of breast, the seat of chronic cystic mastitis, is apparently not more frequent than the normal incidence of cancer in the same number of women at the same age, who had not been operated on: three out of 128 cases—about 2 per cent.

Two of these patients died of cancer, both of whom were operated on by outside surgeons; one, my own patient, is living seven years after the operation for cancer.

Conservative Operations for the Different Types of Chronic Cystic Mastitis.—Of 350 cases the tumor only has been excised in 128, or about 37 per cent. I am confident that this is too small a number, and in a second paper I will discuss this in detail.

Clinical Diagnosis.—The essential feature is the palpation of one or more distinct lumps. The diagnosis rests more on this than on any other data to be obtained from the history or examination.

Fig. 14 (Path. No. 14923. BB-13-4 [T]).—Section through zone of breast excised, showing a nonencapsulated area of the puberty-adenomatous hypertrophy type. For microscopic picture, see Figure 32. Result (1921): Well, eight years after excision of zone of breast shown in illustration. See page 494.

Age.—If the patient is 25 years of age or under, this, for practical purposes, almost excludes cancer.

Duration of Tumor.—If the tumor has been present for two or more years and has not grown, and there is no change in the nipple or skin, the chances are that it is benign. But there are sufficient exceptions to this rule in patients over 25 years of age not to justify delay. The lump should be explored: if benign, it should be removed; if malignant, it must be followed at once by the complete operation for cancer.

Multiple Tumors.—One distinct tumor in each breast, or more than one tumor in one or both breasts, still clinically benign, practically makes the diagnosis of a benign lesion. All the types of chronic cystic

mastitis may present the clinical picture of multiple, distinct tumors in one or both breasts. This occurs most frequently with distinct cysts, and less frequently in the other types. Benign encapsulated adenoma of the three types—fibro-adenoma, intracanalicular and cystic adenoma, and lipoma occur as multiple tumors in one or both breasts.

On only two occasions have I observed cancer to begin simultaneously in both breasts. In these two instances, the clinical picture was malignant, because the patient had delayed seeking advice. In a very few cases of malignant tumor, there have been two or more palpable masses in the breast. However, in every case one or more of the distinct tumors have been clinically malignant, that is, associated with changes in the skin or retraction of the nipple. Therefore, the

Fig. 15 (Path. No. 26771. BB-13-5 [T]).—Section through nonencapsulated area of breast containing two slightly dilated ducts with yellow, cheesy, granular contents, two minute cysts, adenomatous areas and mastitis. For microscopic pictures, see Figures 63, 67 and 68. Result (1921): Well, ten months after excision of affected zone of breast. See page 499.

palpation of two or more tumors in one or both breasts, still clinically benign, may be looked on as evidence that they are pathologically benign. However, it might be safer, unless one has had a large experience, to explore and remove one of the tumors.

To make the mistake of diagnosing multiple tumors benign when they are really pathologically malignant, would, from my evidence, not be losing an opportunity to save a life. We have never cured a case of cancer in which the tumors were multiple and malignant.

Single Definite Tumor Associated With Multiple Indefinite Nodules, or Multiple Shotlike Nodules in One or Both Breasts.—This finding.

which, in my experience, is a definite clinical picture, rests on the most careful palpation of both breasts, a refined sense of touch and experience. This clinical picture does not exclude the possibility that the single tumor may be malignant. It indicates that the larger probabilities are that the entire pathologic process is benign and due to chronic cystic mastitis. The single definite tumor, unless clinically malignant, should be explored. If clinically malignant, the complete operation for cancer should be performed.

No Definite Tumor in Either Breast, but Multiple Indefinite Nodules, or Small, Shotlike Nodules in Both Breasts.—Among our 350 cases of chronic cystic mastitis, all in the groups BB-13-4 and -5, a number of patients have presented this clinical picture, and one or both breasts have been unnecessarily removed. I now have records

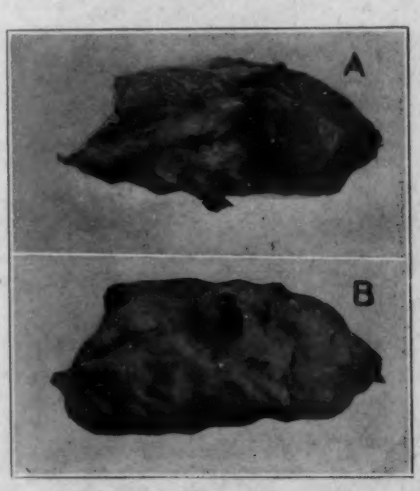

Fig. 16 (Path. No. 19767. BB-13-6 [B]).—Dilatation of ducts beneath the nipple. The section of the breast beneath the nipple shows a small dilated duct with thick wall surrounded by fibrous breast stroma and, in each illustration, a wormlike, brown mass of viscid granular material projecting from the breast tissue. This material represents the wormlike contents of the ducts. Result (1921): Well, five years after excision of the breast. See page 503.

of forty-four cases with the identical clinical picture in which I have advised against operation; and these patients, followed for fifteen or less years, have not developed cancer. This is a larger number than those subjected to operation in groups BB-13 (-4 and -5).

Important Facts in Previous History.—If we can obtain a definite history of a disappearing tumor, or of variation in size of the present palpable tumor, this favors the diagnosis of chronic cystic mastitis. Such a history has been obtained in less than 1 per cent. of malignant tumors, and in more than 15 per cent. of well taken histories of chronic mastitis.

The history of the previous excision of one or more benign tumors from either breast is evidence in favor of the assumption that the present tumor is benign, especially if the excised tumor was a blue-domed cyst. Also, when there is a history of excision of one breast for a benign lesion, this favors the diagnosis of benignity in the remaining breast. On the other hand, the history of operation for cancer in one breast favors the diagnosis that the palpable lump in the other breast is malignant.

Single Tumor in One Breast, the Remaining Portion of This and the Other Breast Normal.—On the whole, this is the most frequent clinical picture. If there is a definite tumor, and the patient is 25 years of age, or over, immediate operation is indicated.

Single Tumor, Clinically Malignant.—In a few cases the trained sense of palpation may enable one to recognize malignancy by touch alone. However, in the majority of cases, the diagnosis rests on retraction or fixation of the nipple, atrophy of the subcutaneous fat, dimpling of the skin, adherent or red skin.

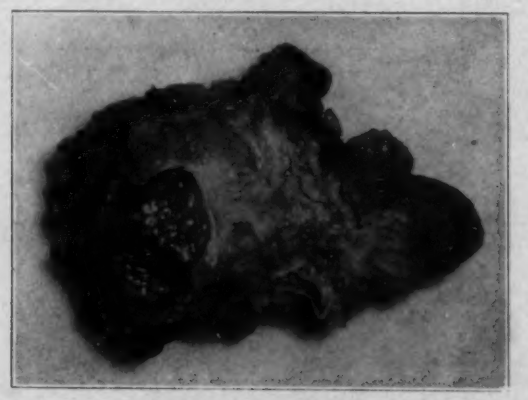

Fig. 17 (Path. No. 24650. BB-13-6 [T]).—Dilatation of ducts beneath nipple. Section through zone of breast excised. Note the slightly dilated, tortuous, unopened duct; the large, collapsed, empty duct, and the dilated duct filled with brown, grumous material. Result (1921): Well, two years after operation. Similar condition in other breast has disappeared. See page 504.

It is true that a certain percentage of benign tumors of all types may give the sensation of malignancy to the palpating finger, or be associated with changes in the nipple or skin, which are usually associated with malignancy. Should the operator perform the complete operation for cancer in all of these benign lesions which present the clinical picture of malignancy, the number of women mutilated would be relatively small.

A large experience will be helpful in the recognition of this benign group and save the patient mutilation. When the palpable tumor is

in the nipple or in the areolar zone, changes in the nipple and skin are less significant of malignancy, than when it is situated outside the nipple zone. This important part of the diagnostic problem will be discussed in detail in a second paper.

Single Tumor Clinically Benign.—Now that women are being educated to seek advice the moment they feel a lump in the breast, this clinical picture is becoming more and more frequent; and at the present time, we have no method of diagnosis, except the palpation of the lump and its exploration. The number of benign tumors in women, more than 25 years of age, in whom it is necessary to remove only

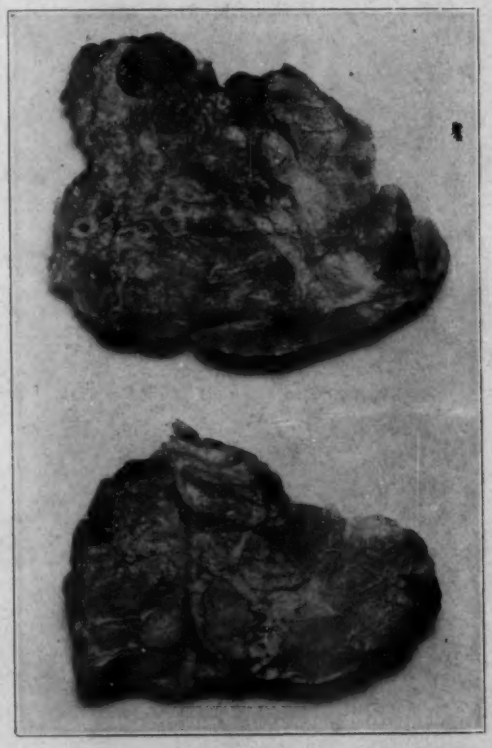

Fig. 18 (Path. No. 27114. BB-13-6 [T]).—Dilatation of ducts beneath the nipple. Section through excised zone of breast beneath nipple shows empty and filled dilated ducts, with a definite ring (the thick wall) surrounded by fibrous breast stroma and fat. In the upper left margin of the upper picture are two large dilated ducts with brown, granular, viscid contents. Result (1921): Well, seven months after excision of zone of breast. See page 507.

the tumor, is too large to justify the removal of the breast, or to perform the complete operation for cancer without first ascertaining the pathology of the palpable lump by exploratory incision. I have records of at least 750 benign lesions of the breast in women, over 25,

of which 350 or almost 50 per cent. belong to the type of chronic cystic mastitis.

In the majority of these cases, both breasts can be saved; and these women run no more risk of cancer than any other group of women of the same age.

Palpation of the Breast.—The educational propaganda is influencing many women to seek immediate advice because of pain or the palpation

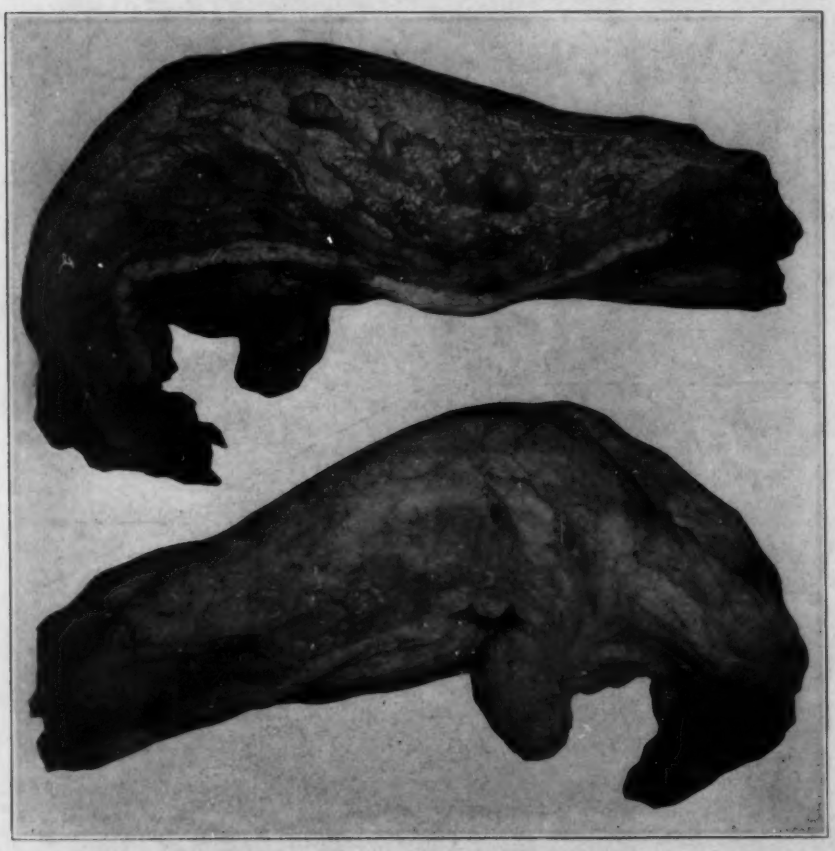

Fig. 19 (Path. No. 21192. BB-13-6 [B]).—Dilatation of ducts in zone of breast outside the nipple area. Section of breast shows chiefly the thick, cream-like material covering the cut surface of the breast, which has been expressed. This obliterates the picture of the dilated ducts. Toward the right edge of the breast one dilated duct and near it a small worm projecting from the duct may be noted. For microscopic appearance, see Figure 78. Result (1921): Well, four years after excision of the breast. See page 511.

of a lump in the breast. I have records of many patients who thought that they had felt a lump, or whose physician had thought he had felt a lump, and who on examination by me were found to have either no lump (sixty-one cases), or a lump which was one of many indefinite

lumps (forty-four cases), or one which was due to simple enlargement of the axillary portion of the breast (twenty-four cases). Here, therefore, we have 129 women who sought advice early because of the educational propaganda, whose breasts on careful palpation presented no indication for operation.

It is therefore of the greatest importance for all members of the profession who assume the responsibility of diagnosing breast lesions to improve their sense of palpation.

Exploratory Incision.—It is my rule always to examine the patient on the day of operation before the area is cleaned, to check up the previous examination and to consider again whether the lump should be explored.

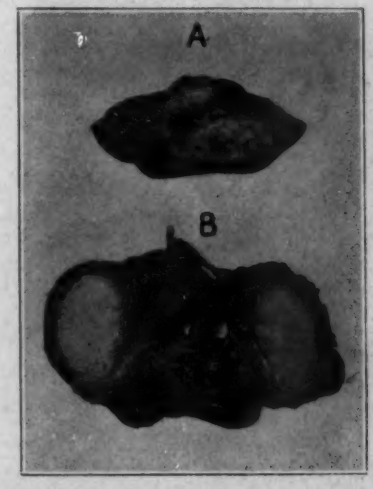

Fig. 20 (Path. No. 27935. BB-13-6 [CC]).—Dilatation of ducts beneath nipple, with abscess formation in one duct: *a*, a section through the breast beneath the nipple, containing dilated ducts with thick wall. In the left margin, there is a small cavity lined by granulation tissue—an abscess due to infection of a dilated duct; *b*, a cross section through an axillary gland; this under the microscope showed no metastasis. Specimen sent by Dr. Loos of Bay City, Texas, who recognized the condition as benign from the gross appearance (recent case). See page 510.

The patient is always prepared for the complete operation for cancer and for general anesthesia. The exploration can be made under procain or gas. One should have on the operating table a medicine glass of pure phenol, one of 95 per cent. alcohol, and a third of 50 per cent. solution of zinc chlorid, with swabs.

The incision should be made directly over the lump. The moment the operator exposes the tumor and concludes that it is malignant, the exposed area should be swabbed with pure phenol followed by alcohol,

the wound packed with a piece of gauze saturated with the zinc chlorid solution, and closed. Then one should proceed at once with the complete operation for cancer.

In a few cases, the palpable lesion is so small, and the breast so large and fatty, that I have excised a zone in which the palpable lump was situated, packed the wound with an alcohol sponge, and then explored the tumor. Up to the present it has proved to be malignant in only one instance. In this case, I burned the wound with the cautery, packed it with zinc chlorid gauze, closed it, and proceeded with the cancer operation. This patient is well (1921), five years since operation.

When the operator feels that he must have a frozen section, what shall be the method? Cut out a piece of the tumor and wait, or cut out a zone of breast about the tumor and wait? I should favor the latter course, that is, to excise the tumor with a good zone of breast and temporarily pack the wound with an alcohol sponge.

Fig. 21 (Path. No. 17012. BB-13-7 [Expl. CC]).—Nonencapsulated cystic adenoma (natural size) and piece of surrounding breast tissue. This tumor has the appearance of cancer. The fine dots and lines on the cut surface may be noted. It felt and cut like cancer. For microscopic appearance, see Figures 90 and 91, which show a benign papillary cystadenoma. Operation (Bloodgood): Exploratory incision followed immediately by the complete operation for cancer. Result (1921): Well, six and one-half years later. See page 515.

Up to the present time, in my own operations, my decision as to the removal of the tumor or the complete operation for cancer has rested on the gross inspection and palpation of the explored lesion, and I have not waited for the frozen section. Each operator must choose his own method, which should be influenced by the results.

What to Do in Case of Doubt.—When one explores a palpable area of the breast and, after gross inspection, with or without the aid of an immediate frozen section, one is still doubtful as to malignancy, I believe the safer rule is to cauterize the area as described and perform the complete operation for cancer. The object of this and subsequent papers is to describe and illustrate the gross and microscopic pathology of the different lesions of the breast, so that we may reduce the number of unnecessary complete operations for benign lesions.

The Mistake That Should Not Be Made.—I am confident from the experience of Dr. Halsted's clinic in Johns Hopkins Hospital since 1899 and from my own cases, and from the tissues and records sent to me by other surgeons, that the mistake of performing an incomplete operation for malignant disease is unnecessary. Cancer of the breast is a distinct gross picture—just as distinct as that in the frozen section—and in this group any surgeon whose experience justifies him in assuming the responsibility for the operation should, and, as far as my records go, does recognize distinct cancer and performs the complete operation.

The Mistake That Is Made and Which Produces No Harm but Mutilation.—This is the complete operation for benign lesions of the breast, especially for chronic cystic mastitis.

Fig. 22 (Path. No. 1210. BB-13-7 [CC]).—Section through nonencapsulated cystic adenoma and surrounding senile breast. Gross description by Bloodgood, in 1896: "Tumors size of twenty-five-cent piece, circumscribed, in places infiltrating; large cellular alveoli divided by fibrous trabeculae. Tumor looked and felt like cancer, but a solid intracystic papilloma is considered possible." For microscopic appearance, see Figure 77, showing benign papillary cystadenoma. Because of the retracted nipple, Dr. Halsted performed the complete operation for cancer. Result: Death from apoplexy at the age of 75, thirteen and one-half years after operation. The glands in the axilla showed no metastasis. See page 513.

This is due to the fact that the relation of chronic cystic mastitis to cancer has been exaggerated in the literature. It is also due to the fact that pathologists disagree as to the histologic picture of the zone of breast about the cyst and of the group BB-13-4 to -8. Some of these nonencapsulated lesions closely resemble cancer (Fig. 21).

Until, therefore, we have established a method of differential diagnosis, the mistake of occasionally performing the complete operation for cancer for doubtful benign lesions is unavoidable.

Among our 350 cases of chronic cystic mastitis, in 210—almost two thirds—the lesion was a distinct cyst, either with a blue dome, or one of the galactocele type. I hope that my description and illustrations will help operators and pathologists to recognize this type and at least save two thirds of the patients with chronic cystic mastitis from the unnecessary removal of one or both breasts.

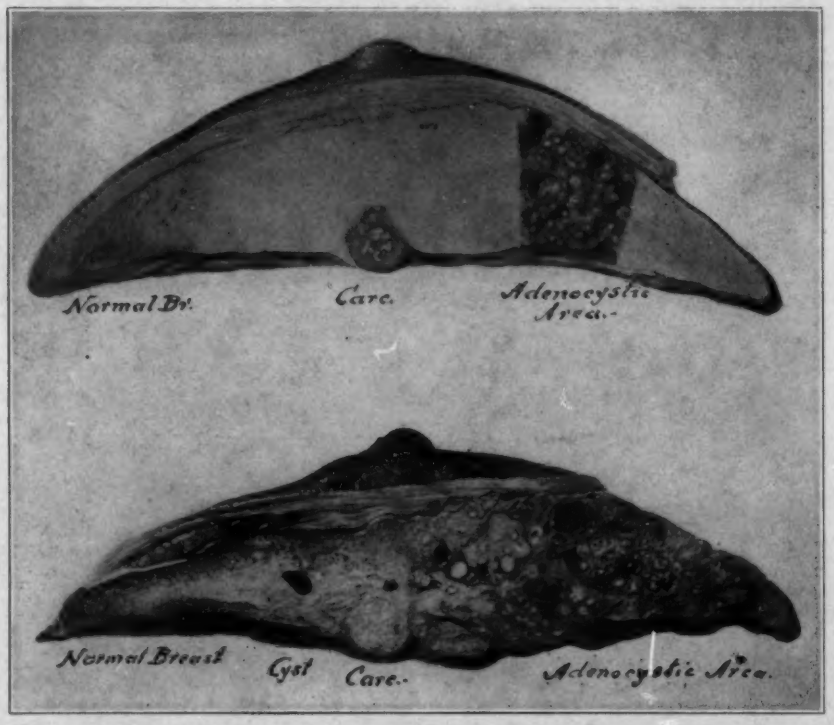

Fig. 23 (Path. No. 3965. BB-13-8 [B]).—Diffuse chronic cystic mastitis of the nonencapsulated cystic adenomatous type. Copy of an original painting of a fresh section through the breast. The involved right half of the breast shows multiple minute cysts with multiple papillomas. The area marked *Carc.* was then considered to be cancer. For microscopic appearance, see Figures 54 and 83—chiefly benign papillary cystadenoma. The zone of breast to the left is adenomatous with a few minute cysts. See page 530.

THE GROSS APPEARANCE OF CHRONIC CYSTIC MASTITIS

1. *The Blue-Domed Cyst in Chronic Cystic Mastitis (BB-12-1)* (Figs. 1 to 7).—Of all the gross types of chronic cystic mastitis this blue-domed cyst is the easiest to recognize and of the most frequent occurrence.

Figure 1 (Path. No. 25508. BB-12-1 [T]) is a reproduction of the photograph of an unopened blue-domed cyst and shows the surrounding breast tissue. The dome was situated directly beneath the subcutaneous fat.

Clinical Note.—This patient was a white woman, aged 39. The lump was accidentally felt in the right breast three weeks before operation. The patient was married; but there had been no pregnancies. The palpable lump in the right breast was in the midzone of the upper and outer quadrant, the size of a twenty-five-cent piece. It was freely movable, distinctly spherical and tense. On careful palpation, definite fluctuation was elicited. At my examination, I felt a second, smaller tumor in the midzone of the upper hemisphere. This lump was freely movable and tense, but of less definite spherical shape than the larger tumor. The skin and nipple were normal. The second tumor had not been felt by the patient. There was no pain or tenderness. The remainder of this, the right, breast and the other breast were normal on palpation.

Fig. 24 (Path. No. 3965. BB-13-8 [B]).—Diffuse chronic cystic mastitis of the nonencapsulated cystic adenomatous type. Section through the involved zone of breast after it had been hardened in liquor formaldehydi, showing chiefly minute cysts with papillomas. Result (1921): Well, twenty years after excision of the breast. See page 530.

The palpation of two tumors in one breast, with the rarest exceptions, indicates benignity. In this instance, both tumors felt like cysts.

At the exploration of the larger tumor, the blue dome of the cyst was immediately exposed after division of the subcutaneous fat and was excised with a zone of breast as shown in Figure 1. The second tumor could be palpated from the wound, and was also excised with a zone of breast. It also presented a distinct blue dome and was buried in breast tissue. In dividing the breast in excising these two tumors, no other cysts were encountered and no dilated ducts. The breast tissue was firm and white, with evidence of adenomatous hypertrophy.

On opening the smaller cyst, it was found to contain clear fluid. The cyst wall was smooth and thin.

On opening the larger cyst, after it had been in liquor formaldehydi and photographed, it was found that its contents had not coagulated (in the cysts of the galactocele type the contents coagulate in the preservative).

Microscopic Note.—The breast tissue surrounding the cyst showed increase of fibrous stroma with many adenomatous areas and here and there a dilated duct. The cyst wall showed no epithelial lining, but in the wall there was lymphoid-cell reaction and adenomatous areas showing mastitis.

Summary of Path. No. 25508.—Clinically this case was considered benign on account of two palpable tumors. Each tumor on palpation suggested a cyst. Pathologically, two blue-domed cysts were found in a fibrous and adenomatous breast, with some evidence of mastitis.

Result.—One year after operation, the patient was well.

Figure 2 (Path. No. 27762. BB-12-1 [T]) is the reproduction of a photograph of an unopened blue-domed cyst and surrounding breast tissue. The thin zone of breast tissue covering the blue dome has been incised, enucleated from the cyst wall and retracted.

Fig. 25 (Path. No. 5221. BB-13-8 [CC]).—Diffuse chronic cystic mastitis of the nonencapsulated cystic-adenomatous type. Section through the breast. The left half shows minute cysts microscopically (Fig. 76) papillary cystadenoma; the right half is adenomatous. Specimen brought to the laboratory by Mr. Schloss, a third-year student. Result (1921): Well, seventeen years after complete operation for cancer. There was no metastasis to the axilla. See page 531.

Clinical Note.—The patient was a white woman, aged 51, unmarried. She was passing through the menopause. The periods had been irregular and scanty for three years. The lump was observed in the right breast three months before operation. There had been no pain. It had not varied in size, nor had there been the history of a disappearing lump. The tumor was in the upper and outer quadrant in the periphery of the breast, the size of a fifty-cent piece, freely movable, tense, smooth, like a cyst, and on most careful palpation showed slight fluctuation. The remainder of this breast and the other breast were normal on palpation.

Diagnosis.—Benign cyst.

Operation.—After dividing the subcutaneous fat, white breast tissue was exposed. The cyst could be palpated beneath. About 2 mm. of breast tissue was divided; and then the blue dome was clearly exposed. The palpable tumor was excised with a zone of breast tissue. In making this excision of breast tissue, two minute blue-domed cysts were exposed and removed. The remaining breast was adenomatous.

Figure 3 (Path. No. 27762) is a section through this blue-domed cyst and surrounding breast. The contents had not coagulated and were slightly cloudy. The wall of the large cyst was thin and smooth. In the illustration, the dark areas are minute blue-domed cysts; the gray areas are adenomatous, and the white areas fibrous breast stroma. There were no dilated ducts.

Result.—Two months after operation the patient was well.

Figure 4 (Path. No. 25560. BB-12-1 [CC]) illustrates a blue-domed cyst surrounded by fatty senile breast. The picture is of the posterior surface, as the cyst rested on the pectoral fascia and was covered with a thin zone of senile, fatty breast.

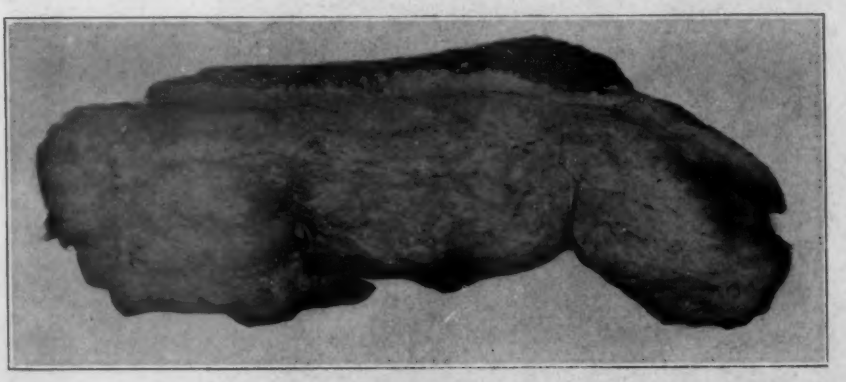

Fig. 26 (Path. No. 26439. BB-13-8 [CC]).—Section through the breast shows that the entire breast is involved—chiefly minute cysts with papillomas. For microscopic picture, see Figures 33 and 56. This case was diagnosed clinically (Bloodgood) in July, 1920, and the complete operation performed by Dr. Seegar at St. Agnes Hospital. The glands showed no metastasis. Result (1921): Well, one year later. See page 537.

Clinical Note.—The patient was a white woman, aged 65, who had passed the menopause many years before. Her attention was directed to the right breast by pain; and she felt a little lump in the periphery of the upper and outer quadrant. This patient had read of the importance of an immediate examination of a lump in the breast and was examined by my colleague Dr. Nichols, who felt the lump. At my examination, I could palpate a rather indefinite lump in the periphery of the upper and outer quadrant of the right breast. The lump did not feel larger than a ten-cent piece: it was buried deeply. Both

breasts were large and fatty, and there were no other lumps, nor indefinite indurated areas. The lump gave the sensation of being spherical and tense and suggested a cyst.

At this age, 65, so many years after the menopause, and in a distinctly fatty and senile breast, the benign cyst is rare, and cancer is the most frequent tumor. However, both Dr. Nichols and I were inclined to the diagnosis of a benign cyst.

Operation.—After dividing a great deal of subcutaneous fat, in which I could recognize only fibrous strands of breast stroma, I did not expose the tumor. Yet, I could palpate it indefinitely in the deeper tissue. After having made quite a deep wound, I came to the conclusion that it would be wiser to perform the complete operation for cancer. No glands were seen or felt in the axillary dissection.

Gross Pathology.—Figure 4 illustrates the blue-domed cyst which I exposed after operation. Later when the cyst was opened, it was found to contain a

Fig. 27 (Path. No. 26046. BB-13-8 [BB]).—Diffuse chronic cystic mastitis of the nonencapsulated cystic-adenomatous type, involving both breasts. Section through both breasts. For microscopic appearance, see Figures 39, 40, 41 and 42. Result (1921): Well, one year after excision of both breasts. See page 536.

cloudy fluid (not coagulated) and a smooth, thin wall. The breast was fatty, with here and there remains of fibrous stroma. Beneath the nipple, there were a few dilated ducts without contents.

Microscopic Pathology.—The cyst wall had no epithelial lining. The breast was composed chiefly of fibrous tissue and fat, with here and there a few senile adenomatous lobules and slightly dilated ducts.

Result.—One year and three months after operation, the patient was well.

Comment.—I am now inclined to the opinion that in this case it would have been justifiable, after the exploratory incision at the point where I stopped, to excise a large zone of fatty breast tissue surrounding the palpable lump, to pack the wound with a gauze sponge saturated in 50 per cent. zinc chlorid solution, and then to explore the tumor. But I was influenced by the rarity of the blue-domed cyst after the menopause.

Figure 5 (Path. No. 10940. BB-12-1 [T]) is the reproduction of a photograph of a section through a blue-domed cyst and the surrounding breast tissue. One can see in the surrounding breast a few dilated ducts. This photograph was taken eleven years ago and represents the first satisfactory picture. At that time, I did not feel justified in excising a blue-domed cyst unopened. Now my evidence convinces me that the blue dome is so characteristic of benignity that one may excise it with a zone of breast tissue unopened, for teaching purposes. It retains its color even in liquor formaldehydi for some days, but loses it the moment it is opened. I have been able to demonstrate the blue dome in excised specimens to a very large number of medical students and postgraduates in the last few years; and these surgeons and students, I am confident, will be able to recognize this typical benign tumor at the exploratory incision. In fact, one of the third-year students who was present at an operation for a breast tumor, performed by a surgeon in his home state, pointed out the blue dome to the

Fig. 28 (Path. No. 14115. BC-4; BB-13-8 [CC]).—Carcinoma and diffuse chronic cystic mastitis of the nonencapsulated cystic-adenomatous type. The entire breast is involved; section through breast showing a few minute cysts, many minute cysts with papillomas, great increase of adenomatous areas, and fibrous stroma. For microscopic appearance, see Figures 88 and 89, which show areas of carcinoma. The glands showed metastasis. The complete operation for cancer was performed by Dr. Finney in 1913 because of the diffuse induration of the breast and marked enlargement of the glands. Result: Death of metastasis to the brain in ten months. See page 537.

operator and apparently was the chief factor in preventing the complete removal of the breast. This specimen is in the laboratory, and its benign character has been confirmed. I have received specimens from three surgeons whom I had instructed on this tumor and who at an exploratory operation recognized the blue dome, excised the cyst with surrounding breast tissue and sent the specimen and history to my laboratory for confirmation of their diagnosis.

Clinical History.—This case is of particular interest, because, in 1910, I excised the blue-domed cyst shown in Figure 5 from the right breast and three years later removed a similar blue-domed cyst from the left breast. It is now (1921) eleven years since the first operation and eight years since the second, and there has been no recurrence. When this patient came under my observation in 1910, she was 38 years of age, and the irregular and scanty menstrual periods gave evidence that she was at an early menopause. She had observed pain and a tumor for three weeks. The tumor was in the midzone of the upper and outer quadrant, the size of a fifty-cent piece. It was freely movable, tense and spherical, and gave to the palpating fingers the sense of indefinite fluctuation. The remainder of this breast and the other breast contained many indefinite irregular nodules.

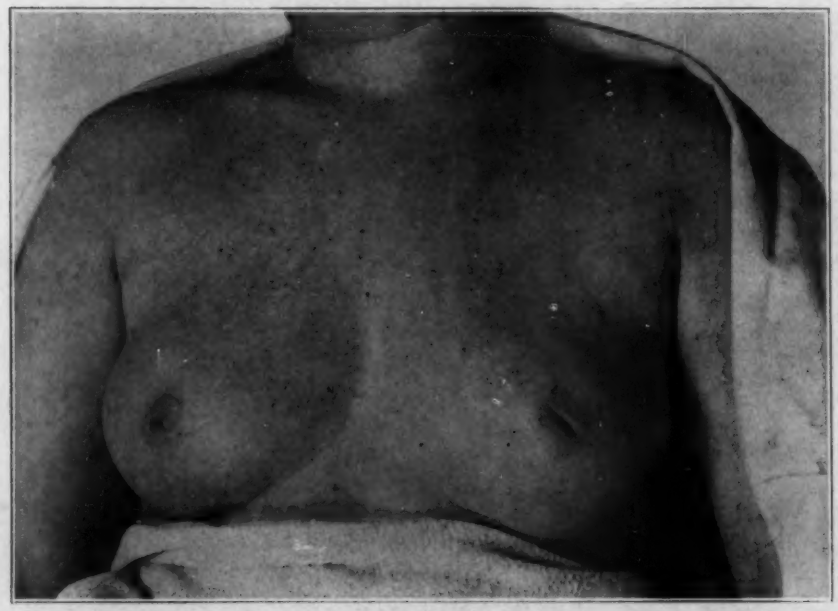

Fig. 29 (Path. No. 12586. BB-13-8 [CC]).—Diffuse chronic cystic mastitis of the nonencapsulated cystic-adenomatous type, showing retraction of left nipple, which had been permanent four months, intermittent for four years. There had been intermittent retraction of the right nipple for four months. Complete operation for cancer on both breasts (Bloodgood). No metastasis to the axilla. For microscopic appearance, see Figures 84 and 85. Result (1921): Well, nine years later. See page 534.

It is very important to note here that the palpation of multiple indefinite nodules in both breasts is very suggestive that the definite tumor is benign.

Operation.—My original notes, in 1910, describe a blue dome after division of the subcutaneous fat. It was about this time that I was beginning to believe that a blue dome was characteristic of a benign cyst. Observations in the eleven years since then have confirmed this conclusion.

This cyst, when opened, contained a cloudy fluid; the wall was 2 mm. thick (Fig. 5) and smooth. Here and there in the smooth wall of the cyst,

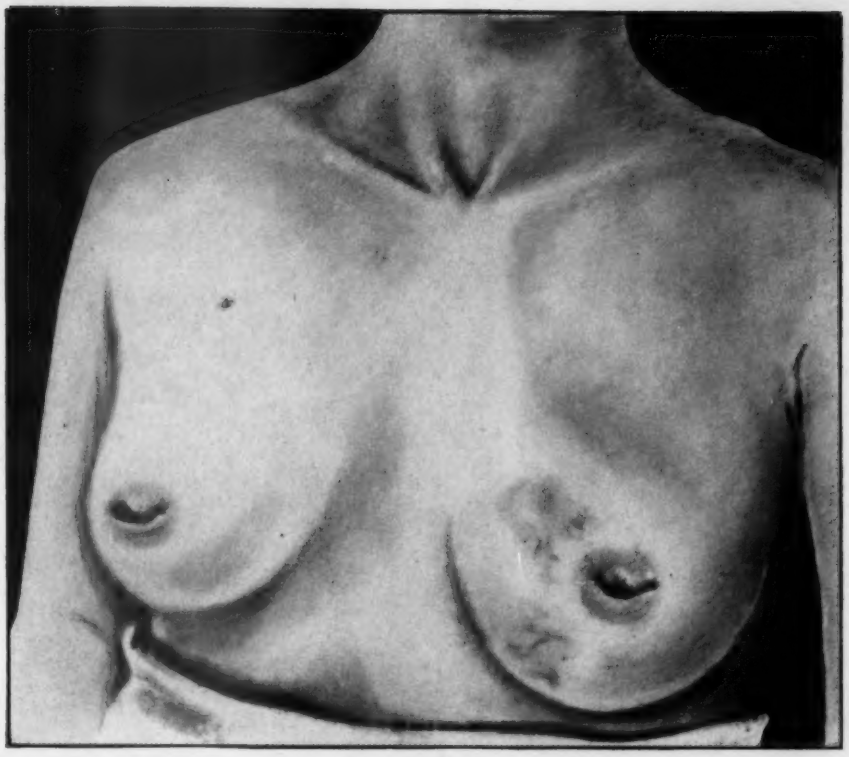

Fig. 30 (Path. No. 11125. BB-13-8 [CC]).—Diffuse nonencapsulated cystic adenoma with the picture of cancer clinically. Copy of painting, showing the bulging tumor, red and infiltrated skin. For gross appearance, see Figure 31.

Fig. 31 (Path. No. 11125. BB-13-8 [CC]).—Diffuse nonencapsulated cystic adenoma with infected cyst producing the clinical picture of cancer (see Fig. 30). Result: Well, ten years after complete operation for cancer.

one could recognize little brown macular areas. Recent microscopic studies have demonstrated that this discoloration is due to minute hemorrhages into the cyst wall (Fig. 46). However, I have never observed the contents of these benign blue-domed cysts to be smoky or hemorrhagic. This blood coloring, if there is no papilloma, is a sign of cancer.

In excising this cyst (Path. No. 10940), I encountered a few dilated ducts beneath the nipple from which could be expressed a creamlike material; and we could express the same material through the nipple. This had not been observed before operation.

Fig. 32 (Path. No. 14156. BB-13-5 [T]).—Normal adenomatous puberty type of chronic cystic mastitis. Section from a nonencapsulated adenomatous nodule in the axillary portion of the breast. For gross appearance see Figure 14. Exploration (Bloodgood) May, 1913; excision of zone of breast only. Result (1921): Well, eight years later. See legend for Figure 72 and page 496.

I wish to emphasize this point here. The exposure of dilated ducts in dividing the breast to remove a blue-domed cyst is not an infrequent occurrence. The contents may be like milk or cream, brown or green. Their presence is *not* an indication to remove the breast.

At the second operation on this patient in 1913, the tumor in the left breast showed a blue dome. Its contents were cloudy, with white débris; and in removing the zone of breast with the cyst, two dilated ducts with milky contents were divided.

The microscopic sections from the breast tissue of both operations in this patient showed many areas of solid adenoma, which some pathologists would interpret in the frozen section as suspicious of malignancy, and advise the complete operation for cancer, or removal of the breast (Figs. 58, 59 and 60).

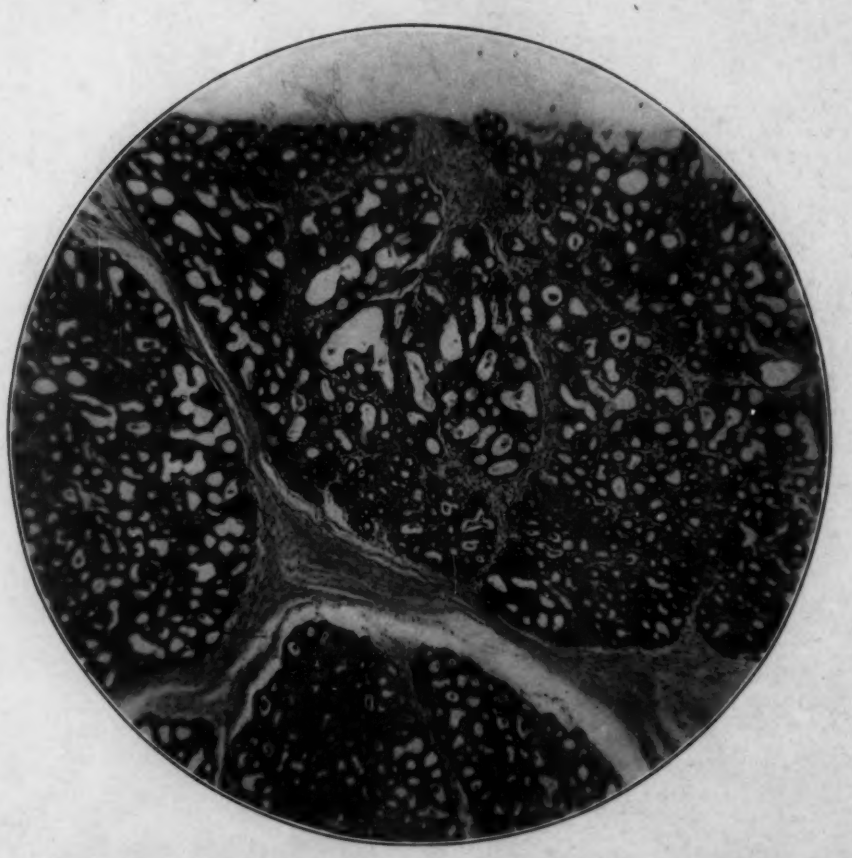

Fig. 33 (Path. No. 26439. BB-14).—Lactation hypertrophy in an encapsulated adenoma, removed from a lactating breast. See page 537.

Figure 6 (Path. No. 27007. BB--12-1 [T]) shows a section through a large blue-domed cyst and the surrounding breast. The cyst has a thin smooth wall, and the little brown macular areas in the surface of the cyst wall are shown. I have described them in the previous case (Fig. 5), and microscopic sections from Path. No. 27007 demonstrated that they were due to small areas of hemorrhage into the wall

of the cyst. The breast surrounding this cyst is chiefly fibrous and fatty. In the picture, the white areas are fibrous; and in this white area, fat can be seen. There is one dilated duct shown and one minute cyst. The adenomatous areas do not show in the illustration.

Clinical Note.—This blue-domed cyst is interesting because it was larger than usual, a little larger than a silver dollar. It was in the midzone of the outer hemisphere of the right breast and filled a quadrant of the breast. The size made me suspect a malignant tumor—either a cancer cyst or a medullary carcinoma. The tumor, however, was smooth, tense, and somewhat spherical.

Fig. 34 (Path. No. 19982. BB-7).—Section illustrating the picture of a senile breast taken from a nonencapsulated area which had remained unresolved eleven years after the last lactation. The mastitis had not resulted in abscess. The thick-walled ducts indicate the old mastitis, otherwise the section resembles the senile breast. Result (1921): Well, five years after the excision of a zone of breast.

There was distinct fluctuation. It is important to note that a medullary carcinoma or a cancer cyst may give the sensation of fluctuation. I found, however, in addition, multiple indefinite nodules in the remaining portion of the right and in the left breast. This finding favored a benign cyst.

The patient was 45 years of age, and had had one child with normal lactation. The lump had been discovered accidentally nine weeks before operation, and the patient had noted no increase in size. If her observation was correct, this suggested a benign cyst. Only this type of breast tumor can reach such a size in such a short time and then remain stationary. The patient had not observed any variation in size. The skin and nipple were normal. My clinical diagnosis was benign cyst.

Fig. 35 (Path. No. 6686. BB-13-4 [T]).—Fibro-adenomatous area in section from a nonencapsulated adenoma excised with a zone of breast by Dr. Finney in 1905. For gross appearance, see Figure 13. Result (1921): Well, sixteen years later.

Operation.—The typical blue dome was exposed the moment the subcutaneous fat was divided; but on account of the size of the cyst, I immediately

opened it. Its contents were cloudy fluid. I then made a frozen section and found no evidence of malignancy in the cyst wall.

Result.—Five months after operation, the patient was well.

Figure 7 (Path. No. 21770. BB-12-1 [T]) is the reproduction of a photograph of a blue-domed cyst and surrounding breast tissue.

Figure 8 shows a section through the specimen shown in Figure 7, illustrating two blue-domed cysts with sourrounding breast. The breast is very adenomatous with a few minute cysts.

Fig. 36 (Path. No. 8717. BB-12-3 [B]).—Intracanalicular-adenomatous area in a breast containing multiple blue-domed cysts. Result (1921): Well, fifteen years after excision of the breast (Bloodgood).

Clinical Note.—This patient was a white woman, aged 29. Six years previously I had removed a similar blue-domed cyst from the right breast; she was then 23, and represented one of the youngest patients in this group. There had been no recurrence in the right breast; but she had observed a lump in the upper and outer quadrant of the midzone of the left breast. The lump was about the size of a twenty-five-cent piece, tense and smooth, slightly lobular,

suggesting an adenoma, or two cysts. Both breasts contained indefinite multiple nodules which had not been noted at the previous examination six years before.

Operation.—After dividing the subcutaneous fat, a typical blue dome was exposed. In excising the tumor with a zone of breast, the breast tissue was found to be very adenomatous; and between the tumor and the nipple, I divided two dilated ducts filled with grayish-brown pastil material.

Microscopic Pathology (Fig. 47).—You will observe from this section that the breast surrounding the blue-domed cyst shows the papillary cystadenoma of chronic cystic mastitis, which is less frequently found to such an extent about

Fig. 37 (Path. No. 16133. BB-12-1 [T]).—Aberrant-adenomatous area in the wall of a blue-domed cyst. Result (1921): Well, seven years after excision of the cyst with zone of breast.

the blue-domed cyst, but is more characteristic of the type usually called Schimmelbusch's or Réclus's disease (BB-13-8).

Result.—Ten years after the first operation and four years since the second (1921), there was no recurrence.

It is interesting to note that this patient's sister had a similar condition in both breasts for which both breasts were completely removed. The tissues from these two operations were sent to my laboratory.

2. *Cysts of the Galactocele Type (BB-12-2).*—These cysts differ from the blue-domed cysts in the absence of a *blue* dome. The dome is opaque white, and when opened the contents are milky. These cysts can be distinguished from the true galactocele, because they have been observed in women who have never been pregnant, and the surrounding breast shows no gross or microscopic evidence of lactation hypertrophy.

In a few instances, I have observed this cyst alone in the breast. More frequently it has occurred as a smaller second cyst exposed in

Fig. 38 (Path. No. 16392. BB-12-1 [T]).—Irregular adenomatous area with a slightly dilated duct, showing duct adenoma. Section from the wall of a blue-domed cyst. Result (1921): Well, seven years after excision of the cyst with zone of breast.

excising a typical blue-domed cyst. I have already noted that the dilated ducts in chronic cystic mastitis may contain creamlike or milk-like contents (Fig. 5), which cannot be distinguished in the gross from the dilated ducts filled with milk in the galactocele. The contents of the cyst of the galactocele type coagulate when placed in alcohol or

liquor formaldehydi. The contents of the blue-domed cyst do not coagulate, as already noted. The chemistry of the contents of this cyst of the galactocele type I have not studied. The microscopic appearance of its wall and the surrounding breast does not differ from that of the blue-domed cyst. Therefore, the cyst of the galactocele type and dilated ducts filled with milklike or creamlike contents is one of the gross findings of chronic cystic mastitis, and it has no relation to lactation.

Fig. 39 (Path. No. 26046. BB-13-8 [BB]).—Cystic-adenomatous area with some small solid alveolar adenomas. Section from breast, the seat of diffuse chronic cystic mastitis of the nonencapsulated cystic-adenomatous type. For gross appearance, see Figure 27; see also Figures 40, 41 and 42, and page 536.

Figure 9 (Path. No. 26803. BB-12-2 [T]) is the reproduction of a photograph of a section through a cyst of the galactocele type and the surrounding breast.

This specimen was excised and sent to my laboratory unopened for diagnosis. The coagula filling the cyst may be noted. The sur-

rounding breast shows no other cysts or dilated ducts and is composed of a mixture of fat and fibrous breast tissue with numerous adenomatous areas. The illustration, however, shows a few dilated ducts not noted in the description of the gross specimen. The specimen sent to the laboratory was the size of a silver dollar, and I could palpate in the center a spherical tense tumor. On incision, the dome was white, not blue. The cyst wall was a little thicker than usual, 3 mm.; the cyst was small, the size of a 5-cent piece; its contents were milklike and coagulated.

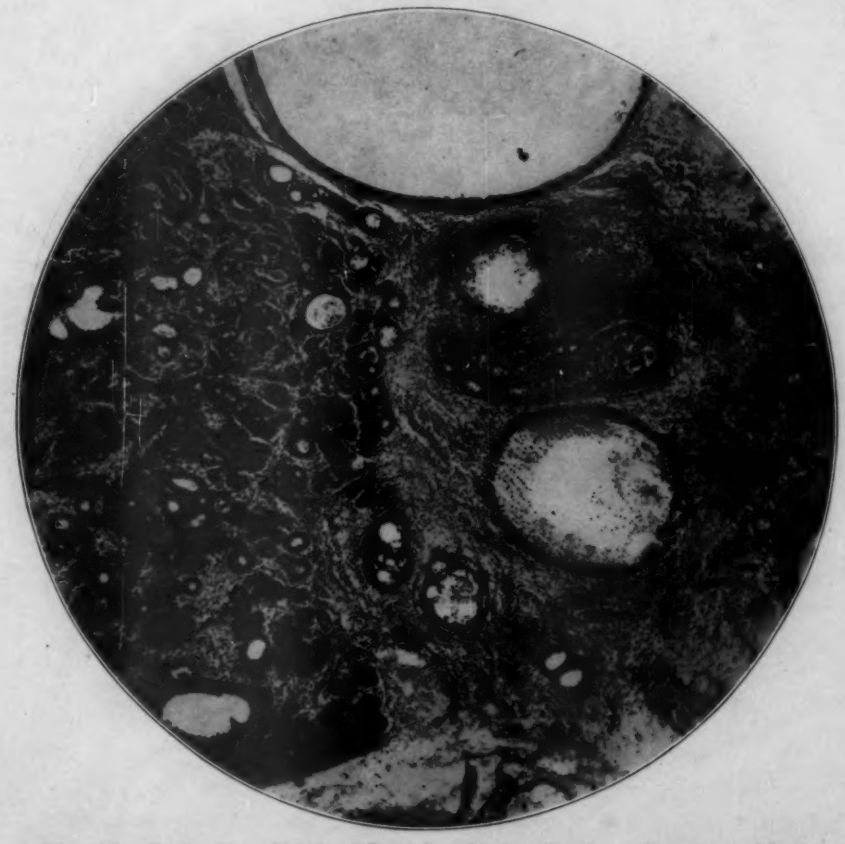

Fig. 40 (Path. No. 26046. BB-13-8 [BB]).—Section showing epithelium-lined cysts, cystic adenoma, small solid adenoma, large duct adenoma, and mastitis. See page 536.

Clinical Note.—The patient was a white woman, aged 23, and had been married one year and seven months without pregnancy. Her breasts had always been tender just before the menses, Five weeks before operation, just before her menses, the right breast was more tender than usual, and she felt a lump the size of a walnut. She immediately consulted her physician who referred her to Dr. A. P. Butt of Davis, W. Va.

The latter excised the palpable lump with a zone of breast tissue and sent it to the laboratory for diagnosis.

Microscopic Pathology.—There was no epithelial lining of the cyst wall. In the surrounding breast, there were a few dilated ducts, cystic adenomatous areas, and here and there ducts and acini plugged with proliferating cells.

Result.—Six months after operation, the patient was well.

Figure 10 (Path. No. 25517. BB-12-2 [T]) shows a section through a cyst of the galactocele type and the surrounding breast. In

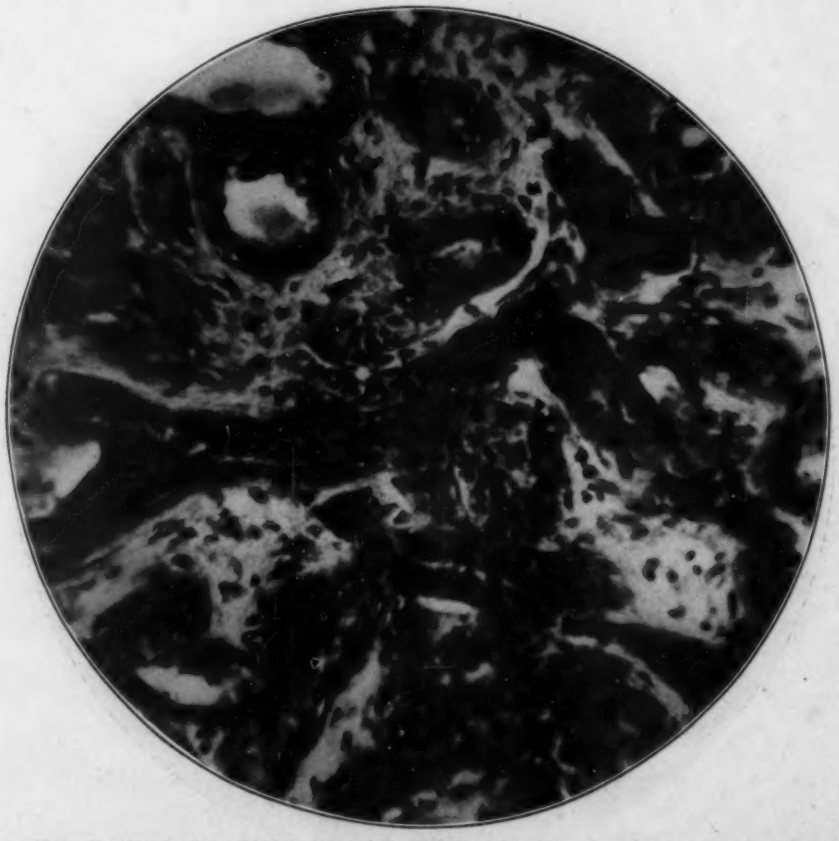

Fig. 41 (Path. No. 26046. BB-13-8 [BB]).—Section showing nonencapsulated diffuse cystic adenoma. High power magnification of irregular stellate solid adenoma. See page 536.

addition, one sees a small dilated duct; the breast was very adenomatous, and there was even gross evidence of chronic mastitis.

Clinical Note.—The patient was a white woman, aged 43. A lump was accidentally discovered four months ago in the left breast. At that time the entire breast was sensitive and apparently swollen. This symptom of onset of breast tumor I have called mastitis. It is not a frequent occurrence. The

clinical picture is similar to that of the "caked" breast of lactation. I have observed it chiefly in chronic cystic mastitis, rarely in comedo-adenoma and never in cancer.[1]

In this case, in a few days, the mastitis subsided and a small lump could be palpated in the periphery of the upper and outer quadrant. The lump was freely movable and the size of a twenty-five-cent piece. It was tense and spherical and suggested a cyst buried in breast tissue. The remainder of this and the other breast were normal on palpation. Her husband, a surgeon, was confident that the palpable tumor had varied in size. This is almost a positive

Fig. 42 (Path. No. 26046. BB-13-8 [BB]).—Section of diffuse nonencapsulated cystic adenoma. High power magnification of large solid duct adenoma. See page 536.

sign of a benign cyst. There had been but one child; but there was no milk in this breast. I had observed this patient four years previously because of a painful breast; but nothing could then be made out on frequent examinations.

1. A restudy of so-called acute carcinoma of the breast may reveal a few cases in which the onset suggested mastitis, but so far no example has been found.

Operation.—On dividing the subcutaneous fat, firm white breast tissue was exposed. On dividing about 4 mm. of this breast tissue, no blue dome was found, but a white opaque dome suggesting a galactocele. On incision, the wall of the cyst was a little thicker than usual, and its contents resembled milk. In excising the breast tissue to remove the tumor, numerous adenomatous areas were encountered, but no other cyst or dilated duct. A minute cyst is seen in the illustration (Fig. 10).

Microscopic Pathology.—The cyst wall had no epithelial lining and was a little thicker than usual (Fig. 44). There was evidence of chronic inflammation, a few minute epithelium-lined cysts, adenomatous areas with ectasia, a few

Fig. 43 (Path. No. 8717. BB-12-3 [B]).—Cystic-adenomatous area (ectasia) from the wall of a blue-domed cyst. Breast contained multiple blue-domed cysts (See also Fig. 36).

dilated ducts, adenomatous areas with mastitis, and some adenomatous areas in which the acini were plugged with cells and which might be considered by some pathologists as suspicious of cancer (duct adenoma, Fig. 59).

Result.—Two years (1921) after operation, the patient was well.

3. *Multiple Blue-Domed Cysts. BB-12-3.*—The multiple cystic disease of the breast, usually bilateral, is a less frequent occurrence than

the single blue-domed cyst. The only difference in the pathology is that the breast is riddled with cysts of various types, usually blue-domed, but some—the smaller—may be of the galactocele type.

In the few cases observed by me, there have always been, clinically, multiple tumors in both breasts, and the condition has been recognized clinically. Formerly, I excised both breasts; recently, I have not subjected these patients to operation at all—a point which will be discussed in the second paper again.

Fig. 44 (Path. No. 25517. BB-12-2 [T]).—Section from the wall of a cyst of the galactocele type; no epithelial lining; wall thickened by chronic inflammatory tissue. For gross appearance, see Figure 10. Result (1921): Well, one year after excision. See page 486.

Figure 11 (Path. No. 26139. BB-12-3) illustrates sections through both breasts after preservation in liquor formaldehydi. One will observe that the gross character of the larger cysts resembles the single cyst illustrated in Figures 3 and 8; that in the breast tissue surrounding these larger cysts, there are more smaller and minute cysts than in the

breast tissue surrounding the single blue-domed cysts in Fgures 3, 6 and 8. The breast tissue itself—not cystic—does not differ from the breast tissue illustrated in Figures 3, 6 and 8.

In this case, the breasts were sent to me by Dr. Royster of Raleigh, N. C., with a note that they were removed from a mulatto woman, aged 39. There were multiple palpable tumors in both breasts, but other details of the history were not obtained.

Microscopic Pathology (Fig. 48).—The most interesting feature is that almost every epithelium-lined duct or acinus of these breasts showed dilatation of varying degrees. The epithelial cells lining the dilated ducts and acini showed proliferation and degeneration. Papillary cyst-adenomatous areas, so characteristic of the group BB-13-7 type, are practically absent.

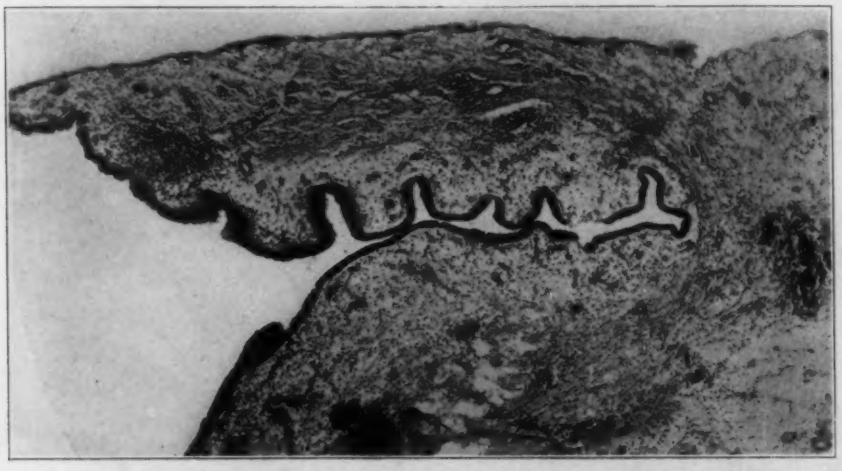

Fig. 45 (Path. No. 27346. BB-12-1 [T]).—Section from a portion of the wall of a blue-domed cyst showing the remains of the epithelial lining and suggesting that the cyst originated in a duct. Result (1921): Well, six months after excision of the cyst and zone of breast.

Figure 12 (Path. No. 4903. BB-12-3) shows a section through the right breast removed in 1903, almost twenty-one years ago, by Dr. Follis at Johns Hopkins Hospital. According to the history, the patient had observed only one tumor in the right breast, of but two weeks' duration. At the examination, it is noted in the history, there was one tumor in the right breast to the outer side of the nipple and a smaller tumor in the same position in the left breast. From the right nipple a few drops of slate-colored fluid could be expressed.

The patient was 39 years of age, and gave the history of a miscarriage fifteen years before observation; there were no other pregnancies, no lactations.

In the laboratory, we could palpate multiple tumors in the right breast. As one cyst could be palpated in the left breast, it is fair to assume that this breast was similarly affected. Nevertheless, at the present time this breast is normal.

This and other observations have led me to conclude that there is no relation between single and multiple blue-domed cysts and the cysts of the galactocele type and carcinoma. If the exploratory incision reveals a cyst of this character, there is apparently no necessity for removing one or both breasts.

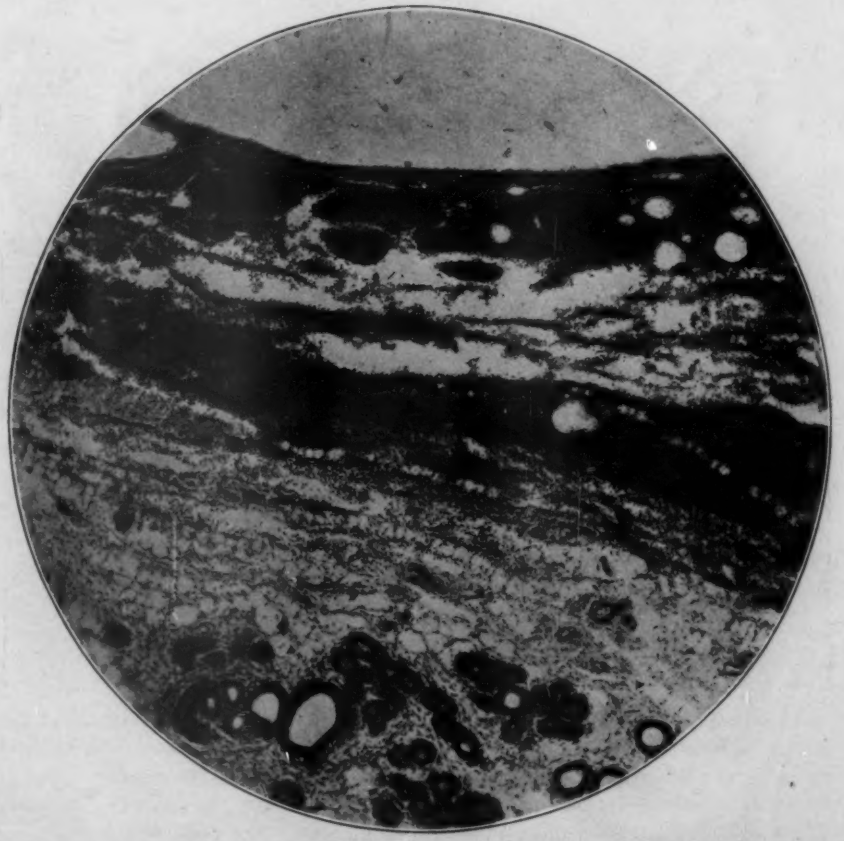

Fig. 46 (Path. No. 26650. BB-12-1 [T]).—Section from the wall of a blue-domed cyst; epithelial lining; dark areas beneath the lining are areas of hemorrhage. (For gross appearance, see Figure 6.) The next zone is granulation tissue, the next contains an area of cystic adenoma. This tumor was of only four days' duration. The cyst contained cloudy fluid, no blood. Result (1921): Well, one year after excision of the cyst and zone of breast. See page 475.

4. *The Nonencapsulated Adenoma in Chronic Cystic Mastitis (BB-13-4).*—In this type, in the explored palpable area there are no visible

cysts or dilated ducts. I first became familiar with its gross appearance in a group of aberrant, encapsulated, benign breast tumors which are observed in young girls at, or shortly after, puberty, and have been classed with fibro-adenoma.

Then, many years ago, before I had the evidence that there was little or no relation between chronic cystic mastitis and carcinoma, I removed both breasts from a patient, aged about 45, because of multiple indefinite nodules in both breasts, of a few months' duration. This was about the time of Warren's publication from Boston; and this case

Fig. 47.—(Path. No. 21770. BB-12-1 [T]).—Section of breast tissue from the wall of a blue-domed cyst. Group of small cysts lined by columnar epithelium; dilated duct; irregular cystic adenoma; lobules of mastitis. See Figures 7 and 8. For microscopic picture of another area, see Figure 55. Result (1921): Well, four years after excision of cyst and zone of breast. See page 480.

seemed to correspond to the bilateral lesion of the breast which he called the "cobble-stone" breast.

When these two breasts were examined, there were no dilated ducts and no cysts, even minute; but each little palpable indefinite nodule could easily be recognized from the surrounding fibrous and fatty breast by a group of elevated pink dots. I have a painting of this specimen; but it is not good enough for reproduction.

Studied microscopically, each of these nonencapsulated areas showed an increase of the parenchyma—a microscopic condition which I have called *adenomatous* (Figs. 32 and 35).

My observation, after the pathologic examination of this case, led me to the conclusion that operation was not indicated in a condition of this kind, when there was nothing to be made out but multiple indefinite nodules in both breasts.

At the present writing I have a record of forty-eight cases with a similar clinical picture in which no operation has been performed. All these patients have been followed, and the multiple indefinite nodules

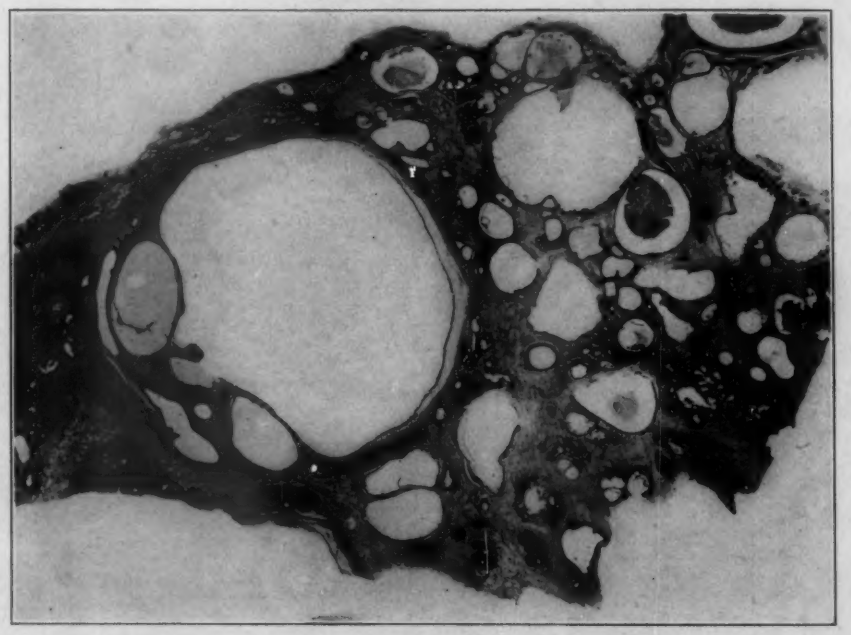

Fig. 48 (Path No. 26139. BB-12-3 [BB]).—Section from breast riddled with multiple blue-domed cysts of all sizes. Both breasts were involved and removed. For gross appearance, see Figure 11; also see page 488.

ultimately disappeared. Apparently, patients in this group run no more, and perhaps less, risk of a cancer of the breast than women at the same age whose breasts are normal on palpation.

Figure 13 (Path. No. 26695. BB-13-4 [T]) shows a gross section through the zone of breast removed. To the right, one sees a zone of breast which differs from the area to the left. In the area to the right, there is more white breast stroma embedded in which are small gray areas. These in the fresh specimen were pink. To the left, the breast has more fat, less stroma and fewer of these areas.

Microscopic Pathology.—The area shown to the right in Figure 13 is filled with irregular adenomatous areas somewhat resembling the benign encapsulated fibro-adenoma. There are no cysts and no dilated ducts. There are a few adenomatous areas with ectasia and a few minute epithelium-lined cysts and two ducts with minute papillomas (in a second section) and one duct with solid adenoma.

Fig. 49 (Path. No. 19994. BB-13-6 [BB]).—Section through zone of breast beneath nipple, showing diffuse dilatation of ducts. For gross appearance, see Figures 16, 17 and 20. Result (1921): Well, seven years later.

Clinical Note.—This patient was a single woman, aged 42. For one year she had been conscious of a small lump in the left breast. There had been no pain. She was still menstruating, apparently normally.

At my examination, I felt a lump, the size of the end of the index finger, in the midzone of the upper and outer quadrant. It corresponded to the lump the patient had felt. I could not palpate in the remainder of this breast, nor in the other breast, any other definite lumps or any area of abnormality. The little lump did not feel tense and spherical like a cyst, but had an irregular outline, and not the hardness of cancer.

At the exploratory incision, Sept. 9, 1920, after dividing the subcutaneous fat, I exposed white breast tissue; but the little lump was difficult to palpate. For this reason, I excised a zone of breast the size of a fifty-cent piece, half of which is shown in Figure 13. This, when sectioned, gave the appearance shown in Figure 13, already described. In cutting this zone of breast out, I encountered no cysts and no dilated ducts. The divided breast tissue was composed chiefly

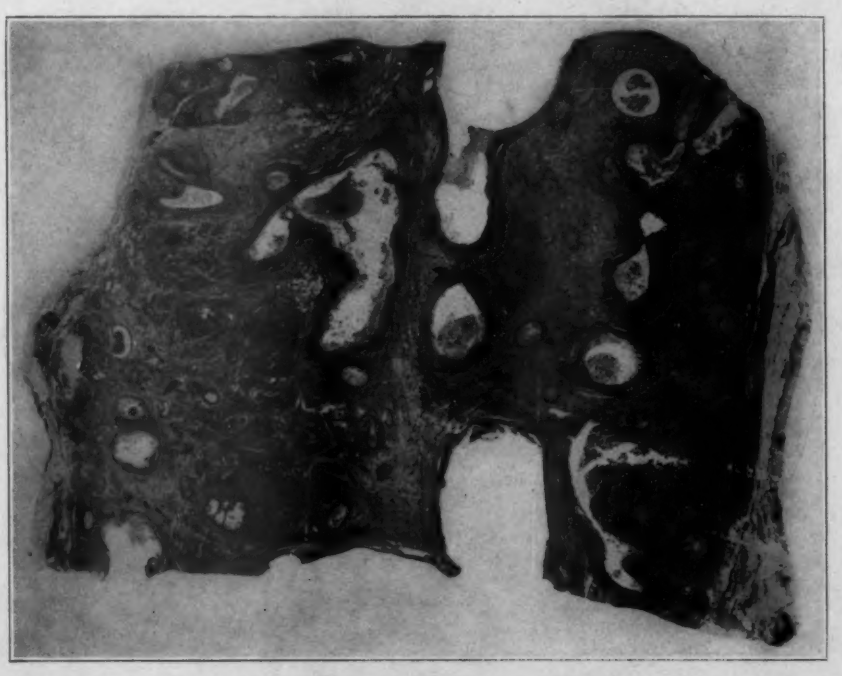

Fig. 50 (Path. No. 21192. BB-13-6 [CC]).—Section of diffuse dilatation of ducts with periductal mastitis involving a zone of breast. For gross appearance, see Figure 19 and page 511.

of fat, with here and there a fibrous strand of stroma. This picture is illustrated in Figure 13 to the left. The wound was then closed in the usual way.

Result.—This patient was well (April, 1921), seven months after operation.

This type, BB-13-4, the nonencapsulated adenoma, was rarely observed until patients were educated to seek advice quickly after the palpation of a lump in the breast. These observations seem to indicate that tumors of this character in the past have disappeared when the patients delayed examination. As noted before, I first observed them

as multiple indefinite nodules, and now, when they appear with this clinical picture, I advise against operation. As a single tumor, I first observed it in 1913, and since then the number has increased.

When the patient, 25 years of age or older, has but a single lump in one breast, operation is indicated at once, because there is no way, at least at the present time, to exclude the possibility of malignancy, except by an exploratory incision.

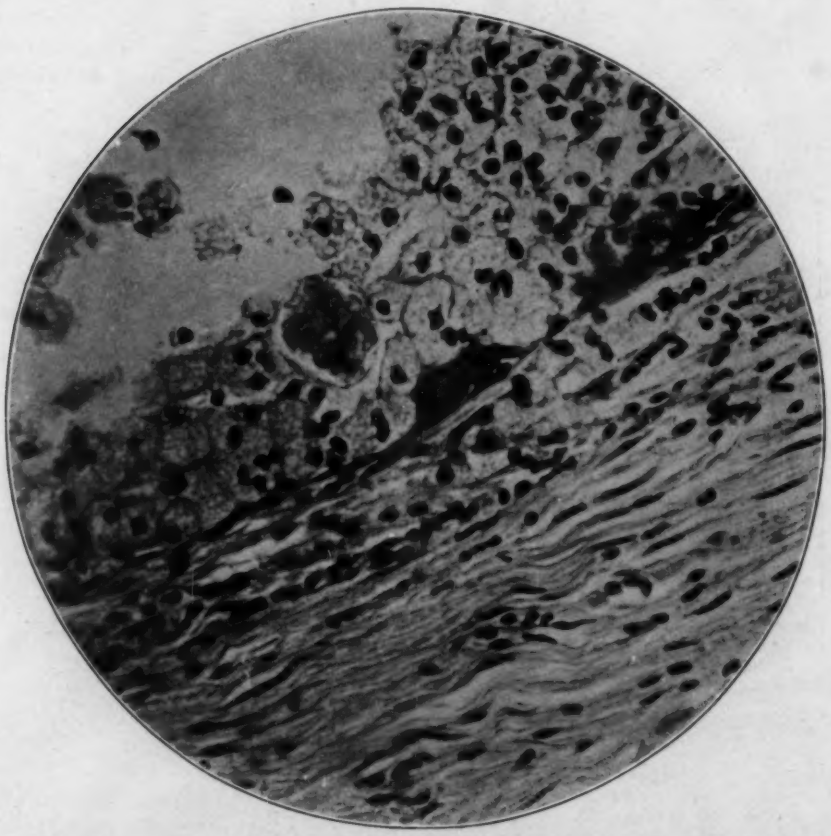

Fig. 51 (Path. No. 21192. BB-13-5 [CC]).—High power magnification of duct shown in Figure 50—desquamating, degenerating cells within the duct and mastitis in the wall. See page 511.

Figure 14 (Path. No. 14923. BB-13-4 [T]) is also a reproduction of a photograph of a zone of breast excised; but it shows the contrast between the nonencapsulated adenomatous area and surrounding breast tissue less distinctly than Figure 13. This is probably due to the fact that the patient was a young unmarried woman, aged 23, while the patient whose specimen is shown in Figure 13 was 42, and breast parenchyma was being largely replaced by fat, except in the tumor area.

Clinical Note.—A white unmarried woman, aged 23, complained of definitely localized pain in the axillary portion of the upper and outer quadrant of the left breast, of three and one-half months' duration. She had palpated the lump for one month.

At my examination in November, 1913, I could make out but one palpable area in the axillary portion of the upper and outer quadrant of the left breast. The remainder of this breast, and the right breast, were of the normal virginal

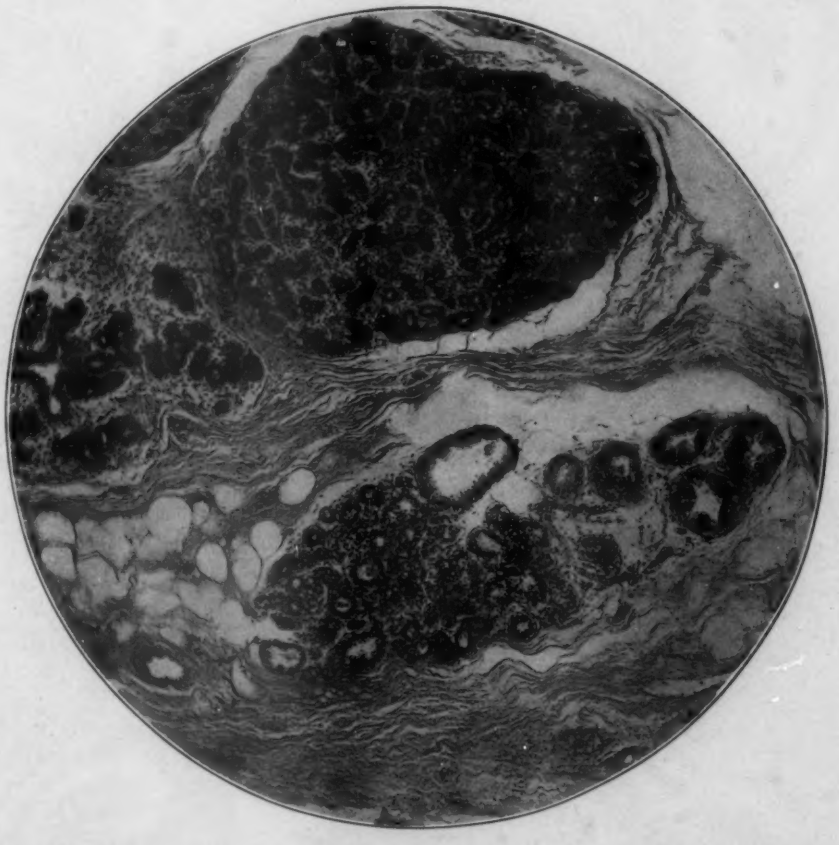

Fig. 52 (Path. No. 16133. BB-12-1 [T]).—Section from the wall of a blue-domed cyst. The lower lobule shows to the right the early stage of alveolar papillary cystadenoma. The left portion of the same lobule shows irregular adenoma with mastitis. The upper lobule shows an aberrant adenomatous area, the right lobule a fibro-adenomatous. Result (1921): Well, seven years after excision of the cyst.

type. The palpable area was indefinite, slightly nodular. It did not feel like an encapsulated tumor or a cyst; but I knew that encapsulated small adenoma buried in breast tissue gave this feeling on palpation.

I advised operation because the patient was about to be married, and as adenomas undergo lactation hypertrophy during pregnancy and may give trouble

by enlargement, it saves the patient discomfort and anxiety when the tumor is removed before this event.

Exploratory Incision.—The palpable area when cut into showed an increase of pink elevated dots as compared with the surrounding normal breast. The area was not encapsulated and was irregular in outline.

Microscopic Pathology.—The section showed chiefly adenomatous areas (Fig. 32). There was some ectasia, a little mastitis, and one area of cystadenoma.

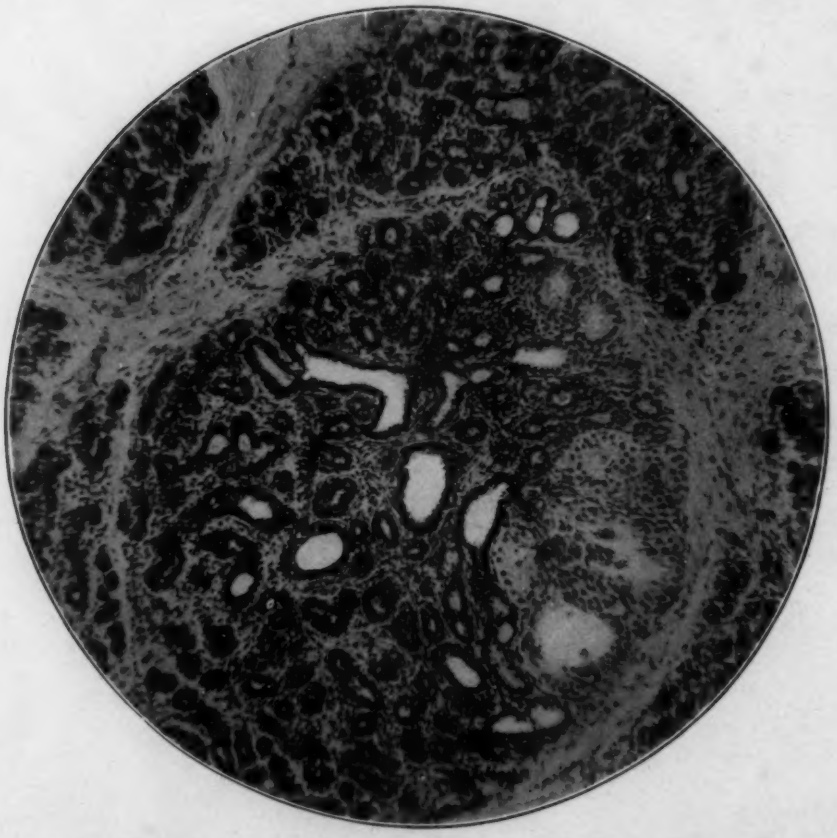

Fig. 53 (Path. No. 11407. BB-13-7 [T-CC]).—Section of a nonencapsulated cystic adenoma. To the right of the lower lobule, an area of alveolar papillary cystadenoma; the remainder of the lobule, cystic adenoma; other lobule, irregular adenoma and solid small alveolar adenoma. This section was first diagnosed adenocarcinoma. First operation: excision of the tumor. Then microscopic examination and twenty-four hours later, second operation: complete for cancer. Result (1921): Well, ten years later. See page 526.

Result.—It is now (1921) eight years since the removal of the zone. The patient is married; there have been two children, and lactation in both breasts was normal.

5. *The Nonencapsulated Adenoma Containing One or More Minute Cysts, or One or More Dilated Ducts, or Both* (*BB-13-5*).—Clinically, this group does not differ from Group BB-13-4; but when one explores the rather indefinite palpable area, one finds, in addition to an irregular, nonencapsulated area shown in Figures 13 and 14, one or more minute cysts or dilated ducts. If the exploration is made slowly and the cyst exposed without cutting it, it has either a blue dome similar to the

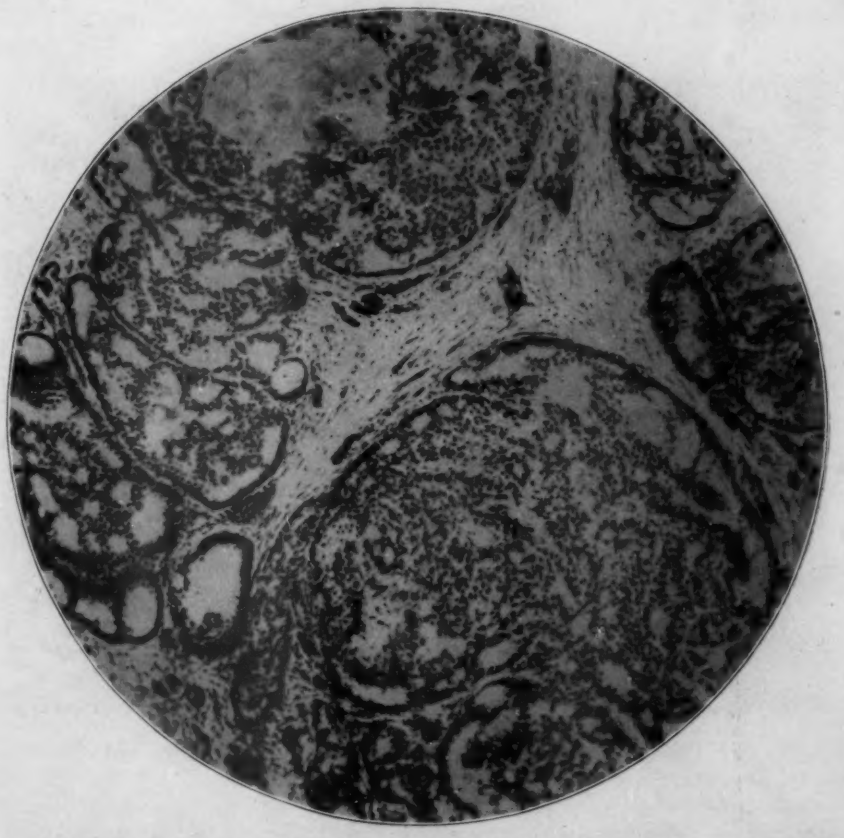

Fig. 54 (Path. No. 3965. BB-13-8 [B]).—Area of papillary cystadenoma from a breast, the seat of diffuse nonencapsulated cystic adenoma. This area was diagnosed in 1901 adenocarcinoma in chronic cystic mastitis. It rested on the pectoral fascia and was removed with but 1 mm. of this tissue, as only the breast was removed. The patient had refused the complete operation. Result (1921): Well, twenty years later. See page 530.

larger blue-domed cysts (Figs. 1, 2 and 4) or an opaque white dome, as shown in Figures 9 and 10, the cyst of the galactocele type. When the cyst is nicked, the contents are either clear, cloudy or milklike. The moment it is nicked, the contents escape, and one can see the wall of the

cyst. When there is a dilated duct, one does not become aware of its presence until the duct is cut across, and one can distinguish the duct from the cyst by the fact that after some material escapes, more can be expressed like pastil material. With the exception of a duct filled with milklike material, its contents differ from those of a cyst. They are more viscid, as if they contained mucin. They have the consistency of a thin syrup. The color varies: it is usually green or brown; it may be creamlike or milklike. When brown, the contents are often granular and slightly cheesy. Then one can recognize the wall of the duct,

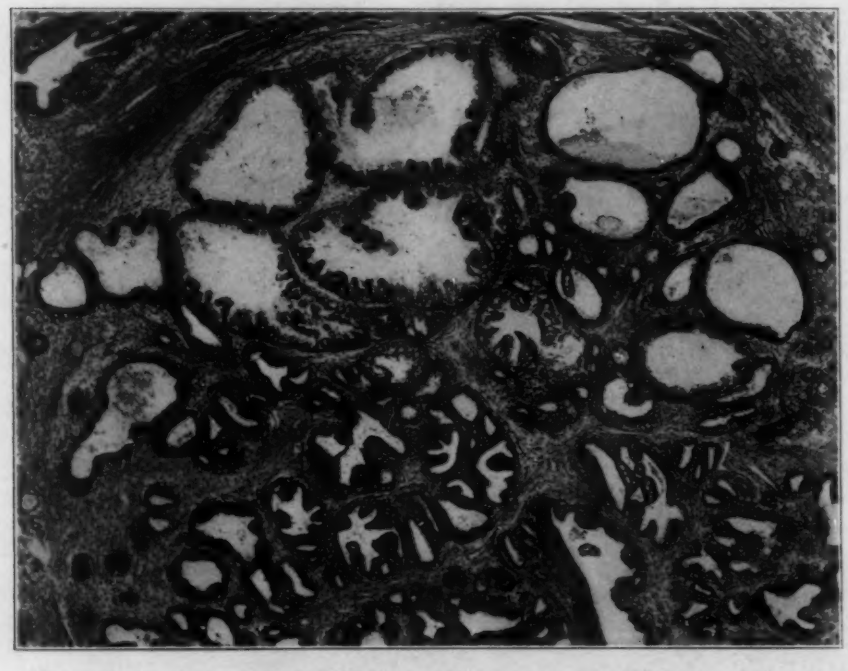

Fig. 55 (Path. No. 21770. BB-12-1 [T]).—Alveolar papillary cystadenoma; cystic adenoma from the wall of a blue-domed cyst (Figs. 7 and 8). This is supposed to be the microscopic picture of diffuse nonencapsulated cystic adenoma, or Schimmelbusch's disease, yet, here it is present as an isolated area in the wall of a blue-domed cyst. Result (1921): Well, four years after excision of the cyst and zone of breast. See page 479.

which is thicker than the wall of the cyst. These dilated ducts with their contents can be easily distinguished from the wormlike masses which are expressed from the comedo-adenoma.

I became familiar with this type first in the examination of breasts which had been completely removed because of a single or multiple palpable tumor. More recently, I have been able to recognize the condition at the exploratory incision, to remove the zone, and save the breast.

Figure 15 (Path. No. 26771. BB-13-5 [T]) shows a section through a zone of breast tissue excised by me, Sept. 23, 1920. It shows both minute cysts and dilated ducts in fibrous and fatty breast tissue and a few adenomatous areas. In the illustration, it is difficult to distinguish the cyst from the duct. Figure 15 should be compared with Figures 13 and 14.

Fig. 56 (Path. No. 26439. BB-13-8 [CC]).—Papillary cystadenoma in ducts. Section of breast, the seat of diffuse nonencapsulated cystic adenoma. For gross appearance, see Figure 26; also see page 537.

Operation.—On dividing the palpable area I exposed two minute blue-domed cysts and divided three dilated ducts filled with yellow, cheesy material. The surrounding breast was chiefly fibrous and fatty. A zone of breast only was excised.

Clinical Note.—The patient was a white woman, aged 50, still menstruating. Two months before operation she noticed pain in the outer half of the right breast and thought she felt a lump. Both disappeared in a few days. At the next menstrual period, one month before observation, she had less discomfort and felt the lump less distinctly. At my examination, I could palpate an indefinite

area in the midzone of the outer hemisphere, corresponding to the area of pain and where the patient had felt the lump. In the remainder of the right breast and in the left breast, I was unable to palpate any other definite or indefinite lump. The palpable lump was no larger than a twenty-five-cent piece. It did not feel like a cyst, nor did it have the hardness of cancer.

Microscopic Pathology.—Usually when there are dilated ducts, we find in the breast surrounding them marked mastitis. This was present in this section (Figs. 67 and 68).

Result.—April, 1921, seven months after operation, the patient was well.

Fig. 57 (Path. No. 20457. BB-13-8 [CC]).—Papillary cystadenoma in duct; epithelium-lined cyst to the left. Section from breast, the seat of diffuse non-encapsulated cystic adenoma (right breast). Excision of breast. Complete operation for cancer on the left breast, two years and eight months later, for diffuse comedo-duct adenoma; no metastasis to the axillary glands. Result (1921): Well, five years after second operation. See page 536.

6. *Diffuse Dilatation of the Ducts, Usually Situated Beneath the Nipple, Rarely Outside the Nipple Zone* (*BB*-13-6).—For many years, I have been familiar with the dilatation of the ducts filled with different

types of material in breasts which had been completely removed for benign or malignant tumors. The tumors were outside the nipple zone, and the dilated ducts had given no evidence of their presence, either by the palpation of a lump in the nipple zone, or by discharge from the nipple. I had always looked on this condition as a feature of chronic cystic mastitis. In about 1897, I assisted Dr. Halsted in exploring an indefinite palpable lump beneath the nipple. I recollect this lump as feeling like a bunch of worms, and my original notes confirm this

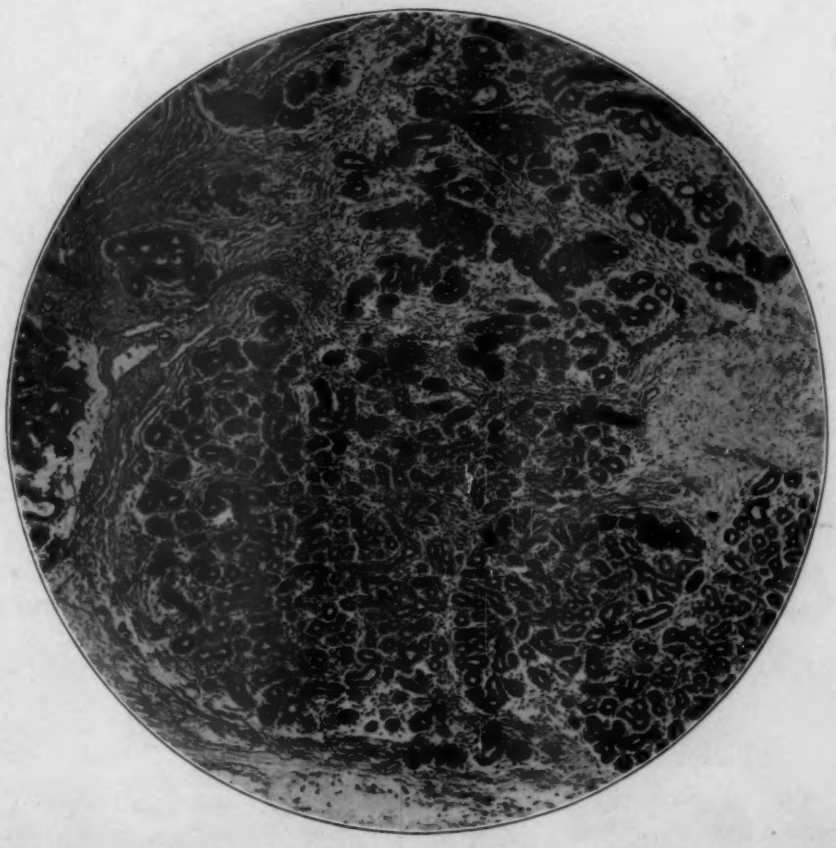

Fig. 58 (Path. No. 22778. BB-13-7 [T]).—Solid small alveolar adenoma. Section from a nonencapsulated cystic adenoma. Small nodule excised in 1915; complete operation for cancer, in 1918, for a second nodule of the same type. No metastasis to the axillary glands. Result (1921): Well, three years after second operation. See page 525.

statement. The indefinite palpable tumor proved to be a dilated duct, with a thick wall about the size of a slate pencil (5 mm.), tortuous and filled with a brown, granular mass. Within a few millimeters of this duct was a minute cyst. At that time we did not look on the condition

found at the exploratory incision as malignant, but concluded that it was safer to perform the complete operation for cancer.

On the gross study of this breast, nothing else was found. The remaining breast tissue was fatty with some fibrous stroma. The sections showed no areas which, even at that time, could be interpreted as suspicious of malignancy, and the sections of the glands showed no metastasis.

Fig. 59 (Path. No. 26650. BB-12-1 [T]).—Large alveolar duct adenoma. Section from the wall of a blue-domed cyst. This picture is frequently called adenocarcinoma. Result (1921): Well, one year after excision of tumor and zone of breast. See page 525.

This was the first case to be placed in this group. Since then, I have recognized this wormlike tumor beneath the nipple in one or both breasts, and, not feeling justified in being conservative, I have removed one or both breasts. Specimens with the identical gross and microscopic pathology have been sent to me by colleagues who had either removed one or both breasts or performed the complete operation for cancer.

Figure 16*a* (Path. No. 19767) illustrates best the character of the contents of the duct when they are granular and can be expressed like a worm. This picture also shows a few ducts from which the contents had been expressed.

Figure 16*b* (Path. No. 19767), from the same breast, shows a very much larger dilated duct, filled with brown, granular, viscid material.

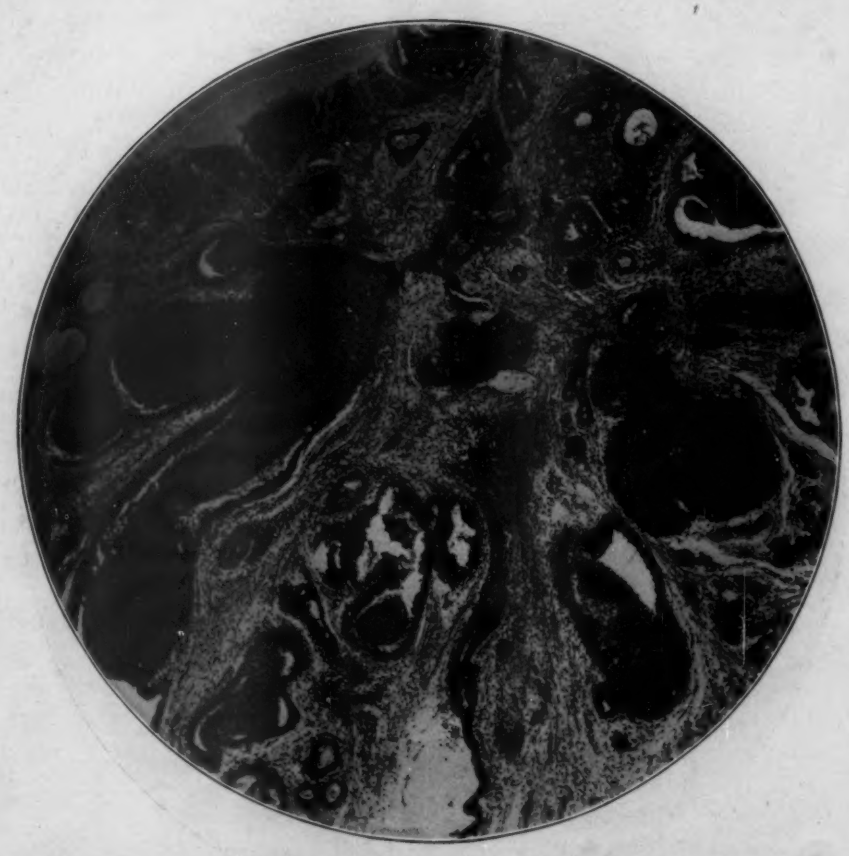

Fig. 60 (Path. No. 1734. BB-13-7 [B-CC]).—Large alveolar duct adenoma. Section from a small nonencapsulated cystic adenoma. Breast explored by Dr. Halsted in 1897 and removed. The small tumor was considered benign. After microscopic study, it was diagnosed adenocarcinoma, and the complete operation for cancer was performed one month after the first operation. The glands showed no metastasis. Result: The patient was followed for sixteen years, and remained well. See page 521.

In the case illustrated in Figures 16*a* and 16*b*, one breast was removed by me in 1916, and at the present writing (1921), five years later, there is no trouble in the remaining breast.

Figure 17 (Path. No. 24650. BB-13-6 [T]) shows a section through a zone of breast beneath the nipple, which I removed in June, 1919. It shows a large dilated duct filled with brown granular material; it is practically identical with Figure 16. In the white fibrous breast to the right, unopened, dilated, tortuous ducts can be seen, and to the right, at the margin of the specimen, a collapsed, empty dilated duct is observed.

Clinical Note.—This patient was a white woman, aged 40. There had been six normal lactations. The last ceased seven months ago, and for some months,

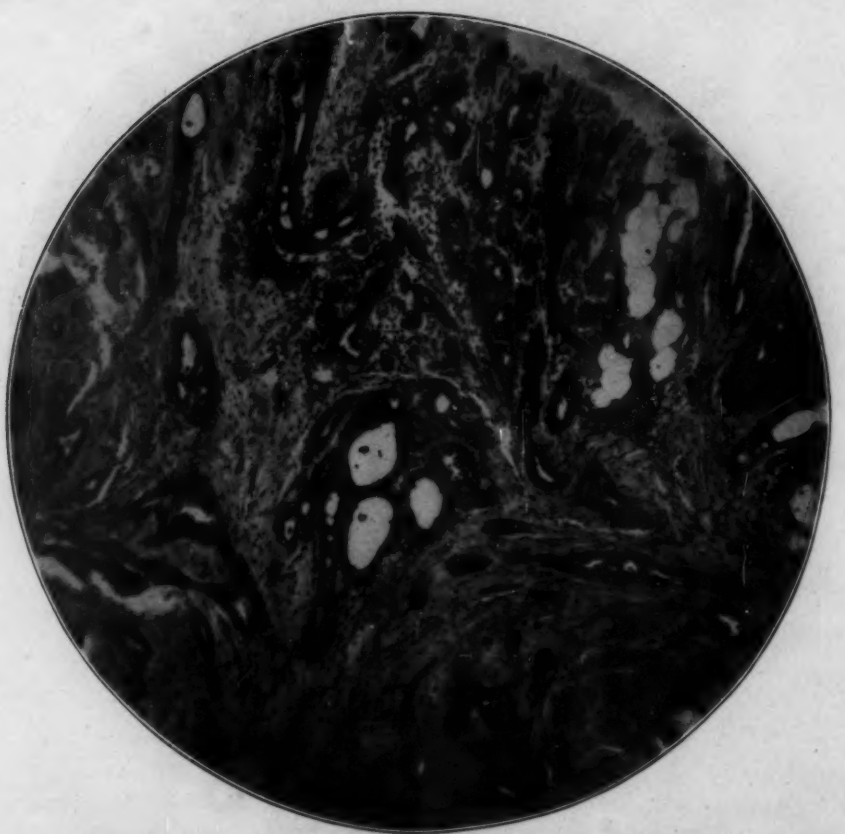

Fig. 61 (Path. No. 13204. BB-13-8 [Expl. CC]).—Small irregular stellate solid adenoma, mixed with cystic adenoma. Section from a breast the seat of diffuse nonencapsulated cystic adenoma. Exploration, gross diagnosis cancer; complete operation for cancer; the glands showed no metastasis. Result (1921): Well, nine years later. See page 536.

she had been conscious of a lump beneath the right nipple. At first, milk could be expressed from the right nipple and then a brownish material.

Examination.—Beneath the right nipple a number of wormlike masses could be palpated. There was no induration. Slightly brownish and milklike material could be expressed from the right nipple. The remainder of this breast was

normal. Beneath the nipple of the left breast, the same condition was present to a very slight degree; but nothing could be expressed through the nipple.

Clinical Diagnosis.—Naturally one thought of galactocele, but I have no record of a true galactocele with a palpable tumor of this character. This patient was observed about seven weeks. The wormlike tumor beneath the right nipple became more distinct, and the material could be expressed from the nipple, although there was no discharge in the interval. The condition of the left breast remained unchanged.

Fig. 62 (Path. No. 8717. BB-12-3 [B]).—Chronic mastitis, alveolar, with atrophy and solid adenoma. Section from the wall of a blue-domed cyst. The breast, the seat of multiple cystic disease, was removed after exploration. Result (1921): Well, thirteen years later. The tumors in the other breast have disappeared.

Operation.—The examination on the operating table revealed a tortuous, wormlike, soft tumor, from perhaps 5 to 8 mm. in size, surrounded by smaller wormlike tumors. There was no induration, no fixation or retraction of the nipple, and nothing could be expressed from the nipple. At the exploratory incision, the larger wormlike tumor had a distinct brown capsule and not a blue

dome. On incision its wall was found to be about 3 mm. thick, and it contained thick brownish material (Figs. 16 and 17). Surrounding this larger dilated duct were other smaller ducts, some of which contained milklike, others brown material. In excising this zone and saving the nipple, the surrounding breast tissue was found to be fibrous and fatty.

It was then nine months since lactation had ceased.

Microscopic Pathology.—The sections show dilated ducts surrounded by lymphoid granulation tissue and a few adenomatous areas with mastitis; but no lactating breast tissue.

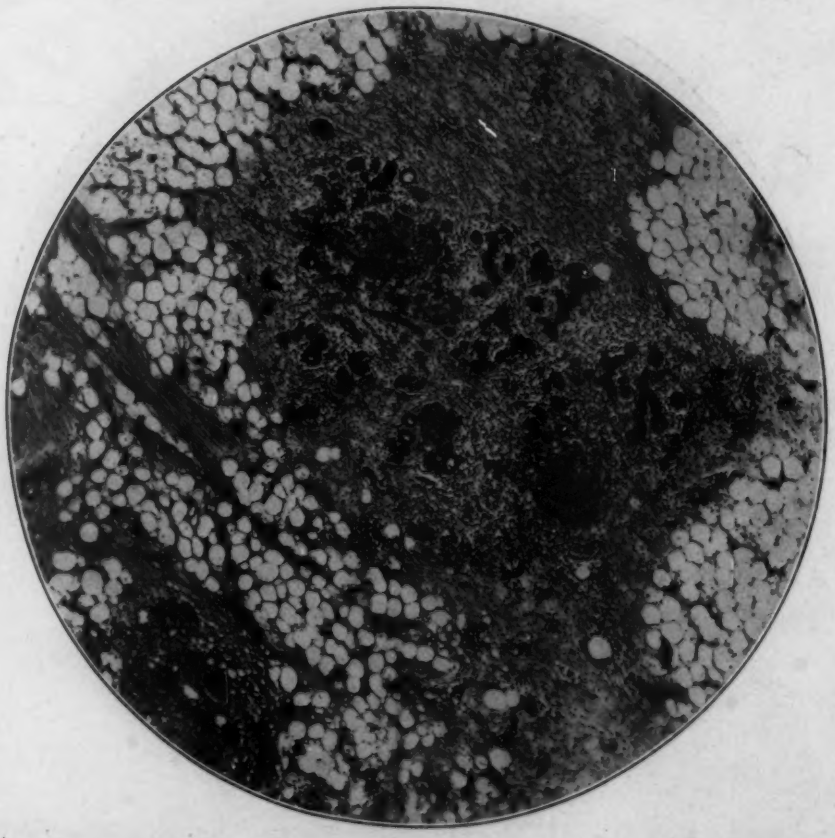

Fig. 63 (Path. No. 26771. BB-13-5 [T]).—Chronic mastitis, alveolar, with solid adenoma and atrophy; also diffuse interstitial. Section from a small nonencapsulated area of breast tissue containing a few dilated ducts and minute cysts. Result (1921): Well, one year after excision of tumor and zone of breast.

Result.—At examination in October, 1919, three and one-half months after operation, the right breast appeared normal. The operation had not interfered with the appearance of the nipple. In spite of the excision of the zone beneath the nipple, there was very little induration. Since operation, she had noticed a

slight brownish discharge from the left nipple, and on examination I found that the slight dilatation of the ducts noted at my first examination had increased.

April, 1921, one year and ten months after operation, her physician, Dr. Ries of Baltimore, reported that the patient was well.

Comment.—This is the first time that I excised only a zone of breast tissue in a condition of this kind. The observation also demonstrates that the left breast, apparently similar to the affected, has done just as well as the right breast operated on. The object of my operation in this case was to exclude carcinoma.

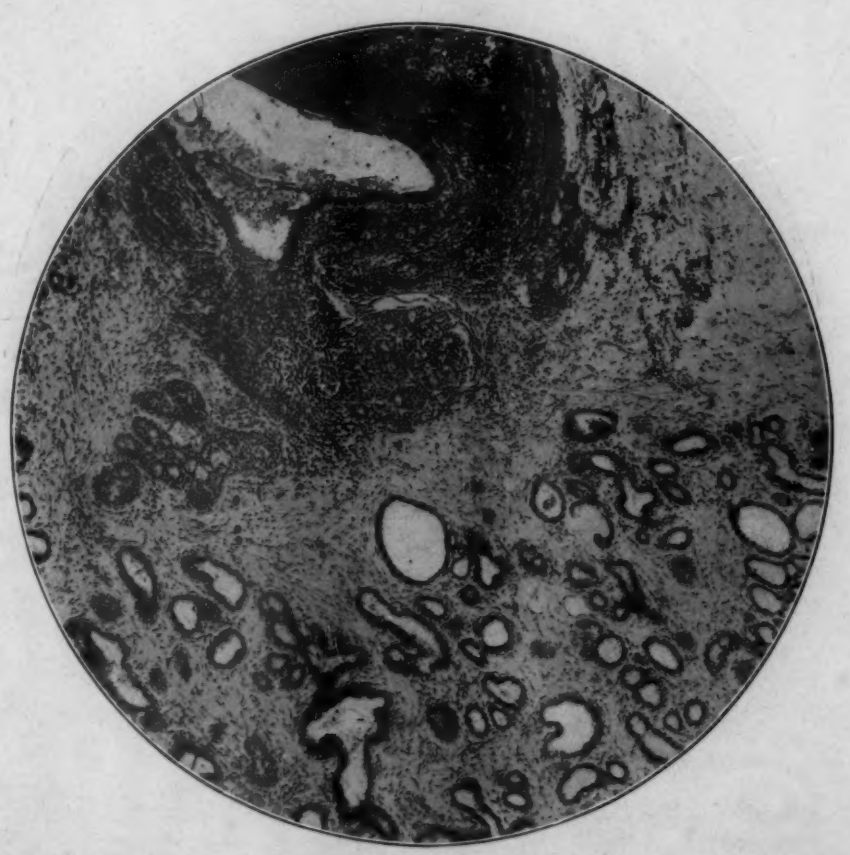

Fig. 64 (Path. No. 1734. BB-13-7 [B-CC]).—Periductal mastitis in upper half of section; cystic adenoma in lower. Section from a nonencapsulated cystic adenoma. See also Figure 60 from the same case, and page 521.

Figure 18 (Path. No. 27114. BB-13-6) shows a section through a zone of breast excised beneath the nipple. In the upper portion of the upper illustration, there is seen the larger duct filled with a brown material, similar to Figures 16 and 17. In the remaining portion of this section and in the lower picture can be seen the smaller dilated ducts

with thick walls. Some of the ducts are empty, some are filled. The surrounding tissue is fatty, with some fibrous breast stroma. There are no cysts and no adenomatous areas.

Microscopic Pathology.—This is similar to that in Path. No. 24650.

Clinical Note.—This patient was a white woman, aged 46. The menses were normal. There had been six normal lactations; the last ceased about four years ago. The patient had observed for about two months a yellowish discharge

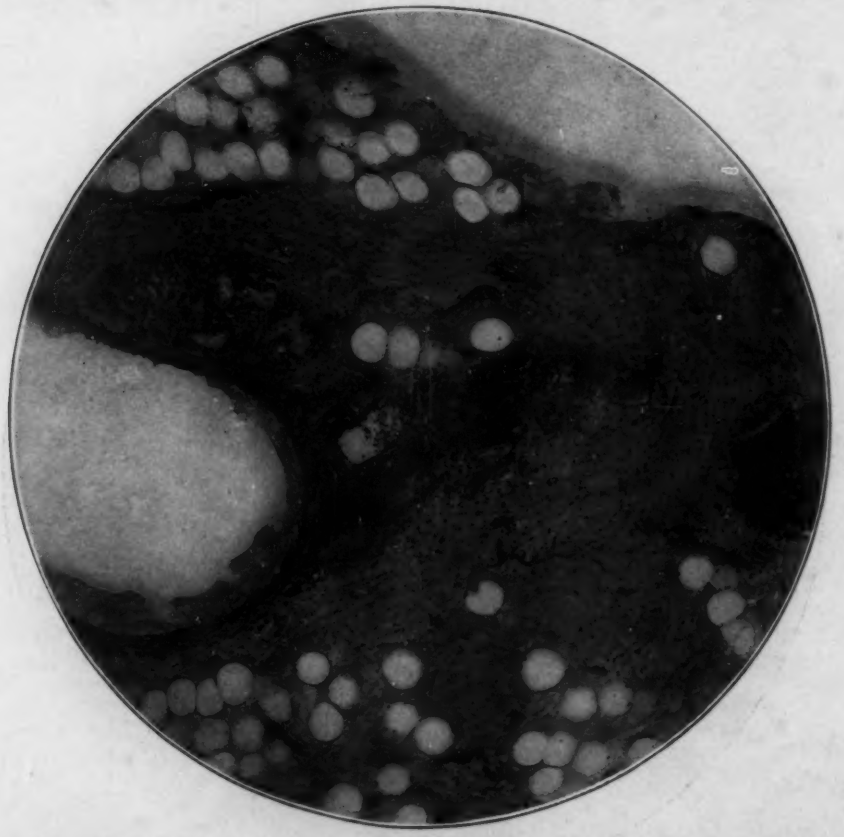

Fig. 65 (Path. No. 19994. BB-13-6 [BB]).—Dilated duct, periductal mastitis; alveolar mastitis with atrophy. From section of breast tissue filled with dilated ducts beneath the nipple. For gross appearance, see Figure 18.

from the left nipple, which had produced a slight eczema and had been diagnosed Paget's disease. There had now been no discharge for one month, and all the signs of irritation had disappeared. The patient had not felt a tumor.

Examination.—Both breasts were very large and had been so since puberty. Beneath the left nipple, there were a number of wormlike, soft masses, and this nipple might be slightly pulled in, but there was no fixation. About the wormlike masses, there was no induration. The remainder of this and the other breast were normal.

Operation.—Nov. 19, 1920, on dividing the fat, numerous dilated, wormlike masses were exposed. Their capsules were brown; some were as large as a slate pencil (5 mm.). On incision, they contained brown, granular material. In cutting out the zone beneath the nipple, other, smaller dilated ducts containing the same material were cut through, and when pressed upon gave the appearance illustrated in Figure 16.

Result.—In 1921, six months since operation, I am informed that the patient is well.

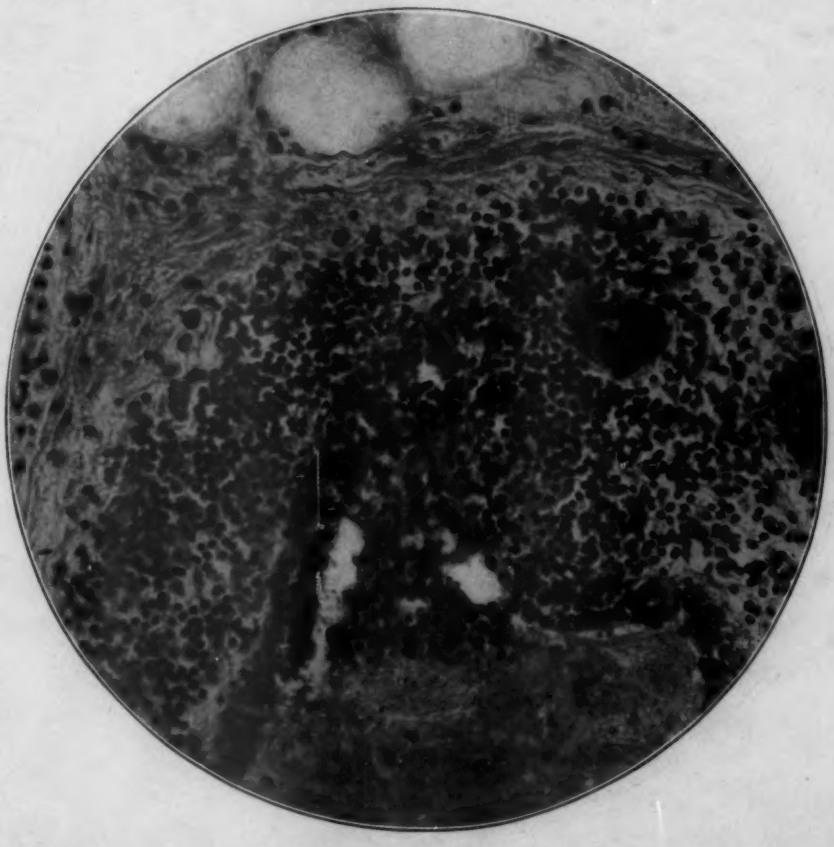

Fig. 66 (Path. No. 19994. BB-13-6 [BB]).—High power magnification of area shown in Figure 65. Dilated duct; periductal mastitis; duct filled with proliferating, degenerating cells; basement membrane destroyed; basal-cell arrangement abnormal, due to inflammatory, not neoplastic, process.

After the operation I took the history again, because the patient had been very nervous before operation. I then found that the slight retraction of the nipple had been observed just before she ceased nursing her youngest child, two and one-half years ago. A clinical finding of this kind excludes retraction of the nipple as a sign of cancer. She had had pain beneath the nipple in the affected breast one year, and then, four or five weeks ago, had noticed the yellow

discharge, following which there was some excoriation of the nipple. In this stage she had been examined in three clinics, with a diagnosis of Paget's disease of the nipple.

Figures 20*a* and 20*b* (Path. No. 27935. BB-12 [6-CC]). Figure 20*a* shows a section through the zone of breast beneath the nipple which illustrates the dilatation of the ducts with their thick walls. Figure 20*b* is a lymph gland from the axilla which is enlarged, due to chronic

Fig. 67 (Path. No. 26771. BB-13-5 [T]).—Alveolar mastitis with atrophy; diffuse interstitial mastitis with zones of granulation tissue. The apparent giant cells are remains of ducts or alveoli. See Figure 68, from same case, and page 500.

lymphadenitis and shows no metastasis. This specimen was sent to me by my former resident surgeon at St. Agnes Hospital, Dr. Loos of Bay City, Texas.

The patient was a white woman, aged 51, with eight children, the youngest, aged 7 years. The menopause had occurred three years before. The onset of the trouble in the breast was sudden, of three weeks' duration. There were pain and swelling of the breast like mastitis; this disappeared at the end of one

week and then recurred. On palpation, a mass was found in the nipple zone the size of a silver dollar. The skin over this area was red. The mass gave the sensation of fluctuation, with a zone of indurated breast about the fluctuating area. There had been a discharge of pus from the nipple for three days, and the nipple was slightly retracted.

On account of this clinical picture, Dr. Loos performed the complete operation for cancer; but on gross study after operation, he concluded that it was benign and due to infection of the dilated ducts beneath the nipple.

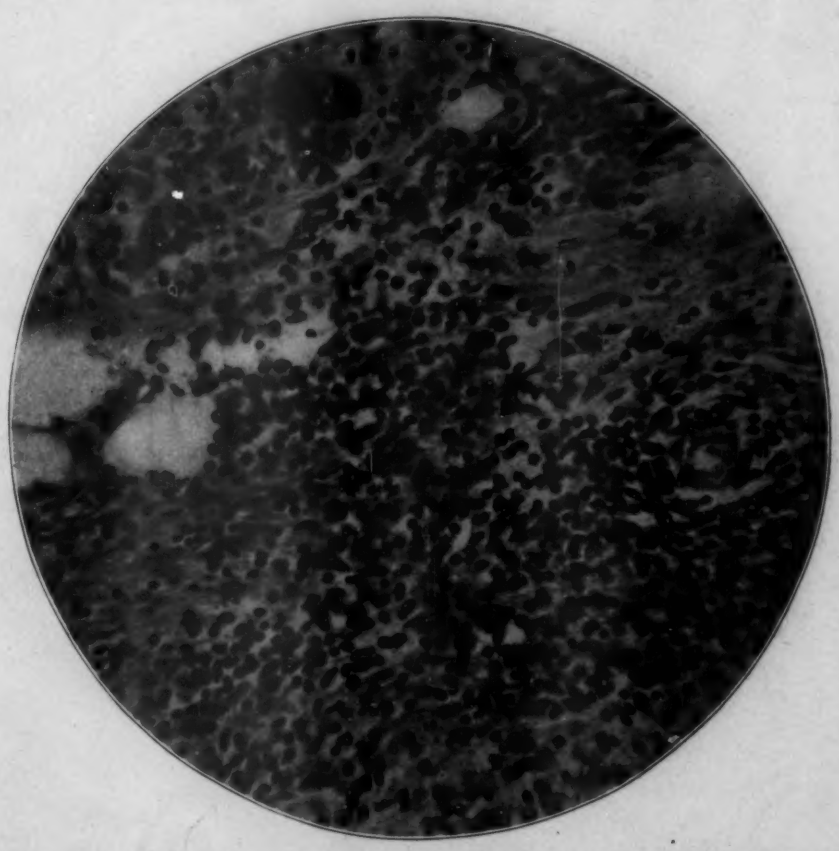

Fig. 68 (Path. No. 26771. BB-13-5 [T]).—High power magnification of area shown in Figure 67. See page 500.

In my experience, cancer never begins as acute mastitis and never gives the clinical picture of an abscess. In this group of BB-13-6 (twenty-two cases), there have been at least three cases with this clinical picture of an abscess due to infection of a dilated duct.

Clinical Note.—In another case (Path. No. 21192. BB-13-6 [B], Figures 19 and 78), the diffuse dilatation of the ducts involved a zone outside the nipple. The onset was similar to that in Path. No. 27935. There were pain and swelling of the right breast, resembling mastitis, of ten days' duration, in a

white woman, aged 51. The menopause had occurred some years previously. The youngest child was 17. The outer hemisphere of the right breast was so hard and swollen that Dr. Hahn, her physician, applied ice. The acute symptoms subsided.

At my examination, ten days after the onset, the skin and nipple were normal. There was a mass in the outer hemisphere of the right breast which felt like "caked" breast in lactation mastitis. However, the edge of the involved hemisphere was not palpable as in BB-13-8, the diffuse nonencapsulated cystic

Fig. 69 (Path. No. 20718. BB-13-4 [B]).—Section from small organized hematoma in a small nonencapsulated adenoma. Breast removed without exploratory incision. Result (1921): Well, five years later.

adenoma, nor were there shotlike nodules to be felt. The condition was undoubtedly subsiding.

At the operation, in March, 1917, I felt it safer to excise the entire breast. The gross appearance is shown in Figure 19. The involved zone of breast is nonencapsulated and distinct from the remainder of the breast, which is fatty and senile. There are no dilated ducts beneath the nipple. The surface of the involved area is covered with milklike, grumous, gray, pastil material, shown in the illustration, which, when wiped away, exposed dilated ducts with thick

walls. The microscopic picture is shown in Figure 78. The ducts were filled with degenerating, desquamating cells, and surrounded by periductal mastitis.

Result.—Four years after operation (1921), the patient was well.

THE NONENCAPSULATED CYSTIC ADENOMA, BB-13-7, EIGHTEEN CASES

The original diagnosis in this case (Path. No. 1210. BB-13-7 [CC], Figures 22 and 77), made in 1896, was adenocarcinoma in

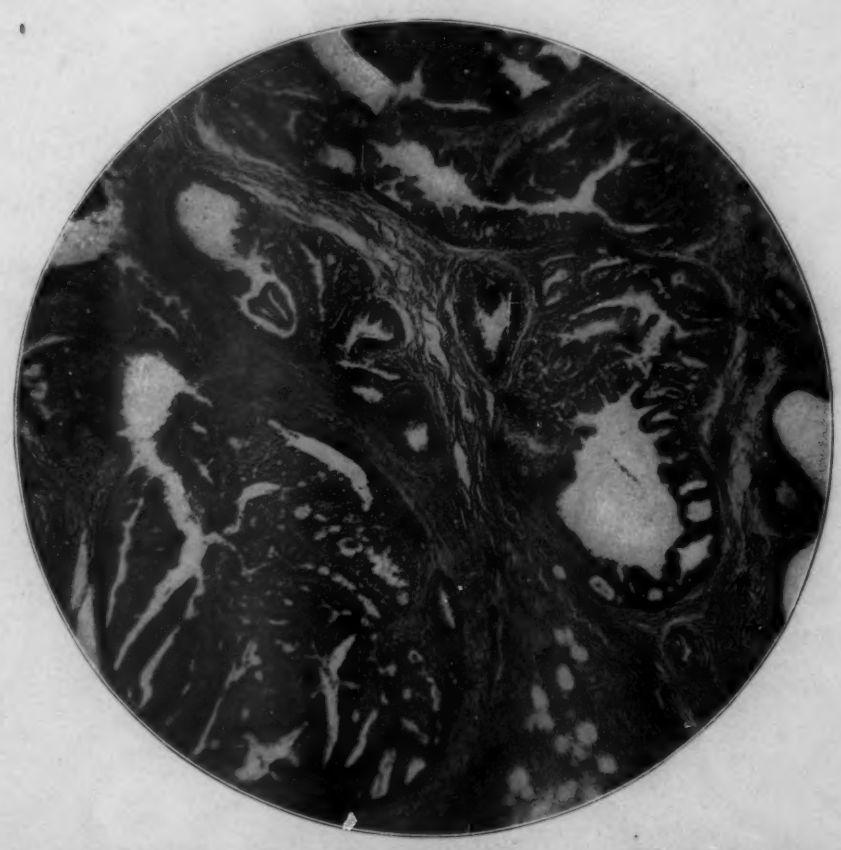

Fig. 70 (Path. No. 12826. BB-13-7 [B-CC]).—Area of papillary cystadenoma. In places, basal-cell arrangement abnormal; basement membrane apparently destroyed. See Figure 71, section from a nonencapsulated cystic adenoma. The operator first removed the breast without exploration; the section was diagnosed adenocarcinoma and the complete operation for cancer performed forty-eight hours later. The glands showed no metastasis. Result (1921): Well, nine years later. See page 525.

nonencapsulated cystic adenoma. But my original note does not describe carcinoma, and restudy of the section discloses no areas of cancer, as shown in Figures 87 and 88.

My original description is as follows: "The tumor (Fig. 22) is the size of a 25-cent piece, not encapsulated; chiefly circumscribed; in places infiltrating; definite fibrous trabeculae surrounding cellular alveoli; no comedones, dilated ducts or cysts." My conclusions, then, from the gross specimen were that the diagnosis rested between medullary cancer and solid intracystic papilloma. The remainder of the breast about

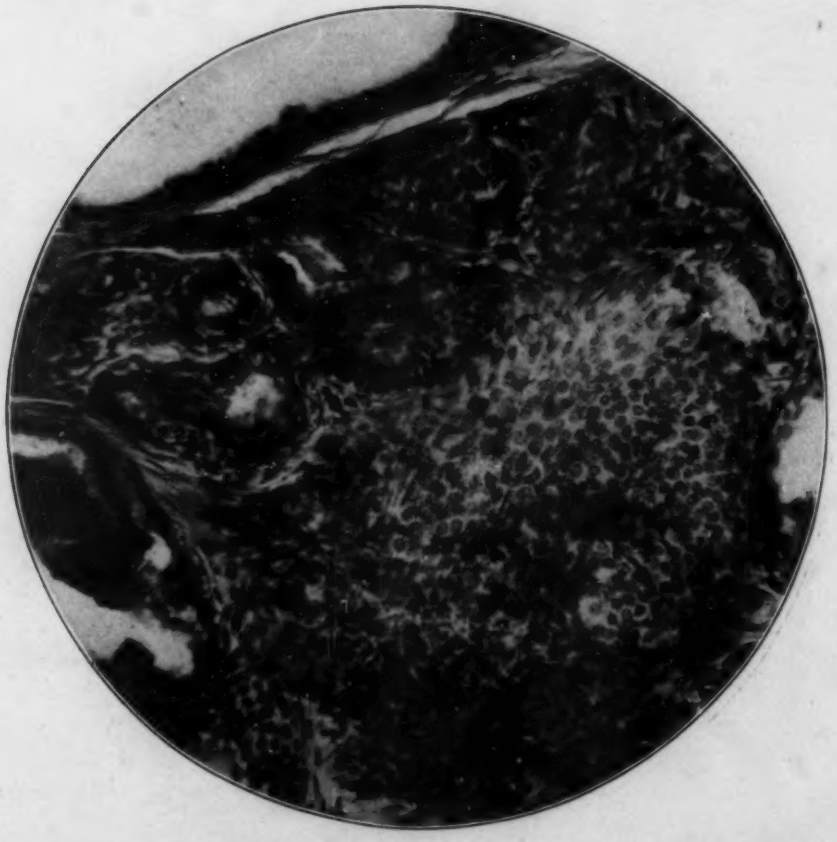

Fig. 71 (Path. No. 12826. BB-13-7 [B-CC]).—High power magnification of area shown in Figure 70, to illustrate the destroyed basement membrane and the abnormal arrangement of the basal cells in some areas.

this nonencapsulated tumor is not described. From what we have now left of the breast in the laboratory, it was a senile fatty breast.

The predominant microscopic picture is shown in Figure 77, papillary cystadenoma. Other portions of the tumor show cystic adenoma, epithelium-lined cysts, irregular adenomatous areas with mastitis. The axillary glands showed no metastasis.

Clinical Note.—This tumor was of ten years' duration in a woman, aged 62. It began just before the menopause, nineteen years after the last lactation. During the last year there had been pain, slight growth, and retraction of the nipple. The tumor felt like a mulberry—hard and lobular—and not like cancer. On account of the retraction of the nipple and the slight atrophy of the subcutaneous fat, Dr. Halsted performed the complete operation for cancer. This patient lived to the age of 75 and died of apoplexy, more than thirteen years after operation.

Fig. 72 (Path. No. 28138. BB-13-7 [T-CC]).—Papillary cystadenoma; basement membrane intact; arrangement of basal cells, normal. Section from a nonencapsulated cystic adenoma. The surgeon explored; the pathologist diagnosed adenocarcinoma; immediate complete operation for cancer was performed. The glands showed no metastasis. Recent case. In 1913, eight years previously, I had removed from this breast a small nonencapsulated adenoma (see Fig. 32). In the interval, there have been two normal lactations. In my opinion, the second operation, complete for cancer, was unnecessary.

I explored the tumor (Path. No. 17012. BB-13-7 [Ex CC], Figs. 21, 90 and 91) shown in Figure 21, in 1915. As it looked and felt like cancer I immediately performed the complete operation. The

glands in the axilla showed no metastasis. The patient is well in 1921, six years after operation.

Clinical Note.—My clinical impression in this case was that I was dealing with a benign tumor because of its long duration—twenty-two years, probably an old adenoma because the patient now aged 42, had felt the tumor at the age of 10. The tumor had not changed during two lactations, the last ten years ago. She came for operation, not because of any change in the tumor, but for the reason that she had read that lumps in the breast should be removed. This tumor, not larger than a ten-cent piece, was in the periphery of the upper and outer quadrant of the right breast, and felt spherical, like a cyst.

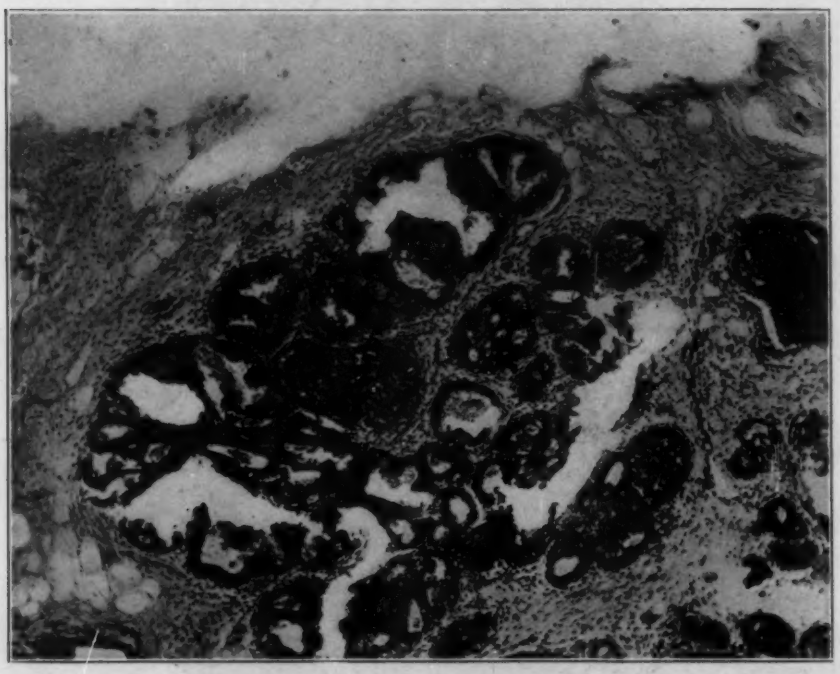

Fig. 73 (Path. No. 14539. BB-12-1 [T]).—Area of papillary cystadenoma and large alveolar duct adenoma; in places, basement membrane destroyed and basal-cell arrangement abnormal. Section from the wall of a blue-domed cyst. Excision of cyst only in 1910. Result (1921): Well, eleven years later. Histologically, this section is more suspicious of malignancy than any other picture among these illustrations. Yet, cancer has not developed since the excision of the cyst.

When exploring, I cut through white, firm breast tissue. The tumor had no capsule. On section (Fig. 21), it appeared circumscribed, opaque-white, with fine, granular dots and lines. It had the hardness of cancer and the surface appearance of cancer; yet, nothing could be expressed from its surface. It never occurred to me that it was not cancer. But, when I studied the sections (Figs. 90 and 91), I found I was dealing with a nonencapsulated cystic adenoma, partly of the solid, small and large adenomatous type; some cystic adenoma (Fig. 90) and some areas of papillary cystadenoma (Fig. 91), resembling somewhat lactation adenoma (Fig. 33).

The Gross Appearance of Nonencapsulated Cystic Adenoma.—Unfortunately among the eighteen cases, these are the only two which we were able to photograph. Of the eighteen cases, eleven have been received from outside sources, seven from the Johns Hopkins Surgical Clinic and one from my own service at St. Agnes Hospital. Of six patients operated on at Johns Hopkins, I either assisted Dr. Halsted at the operation in the early years, or saw the tumor in the laboratory.

Fig. 74 (Path. No. 12451. BB-13-7 [B-CC]).—Papillary cystadenoma; basement membrane destroyed; basal-cell arrangement abnormal. For high power magnification, see Figure 75. Section from an area of nonencapsulated cystic adenoma. The operator considered it benign and removed the breast. The pathologist diagnosed it adenocarcinoma. The complete operation for cancer was performed one month later; the glands showed no metastasis. Result (1921): Well, nine years later. One normal lactation in remaining breast since operation. See page 525.

It seems important to give a detailed description of these cases examined by me, because they represent the type of chronic cystic mastitis most difficult to distinguish from cancer.

Path. No. 468, operation by Dr. Halsted in 1894. The tumor in the upper and outer quadrant was the size of a silver dollar, circumscribed, but not encapsulated. On section, it appeared largely composed of minute cysts containing gelatinous material. Between the cysts, there were white granular alveoli separated by fibrous trabeculae. That is, it resembled Figure 22, except that the tumor contained cysts. In the center of this tumor, there was a calcified area. I might note here that I have never seen calcification in cancer, only in old fibro-adenomas. The microscopic section showed cystic adenoma, fibro-adenoma, a few areas of papillary cystadenoma, calcification and mastitis. The original diagnosis was adenocarcinoma in old adenofibroma. The glands showed no metastasis. This patient lived nineteen years and died of old age, at 74.

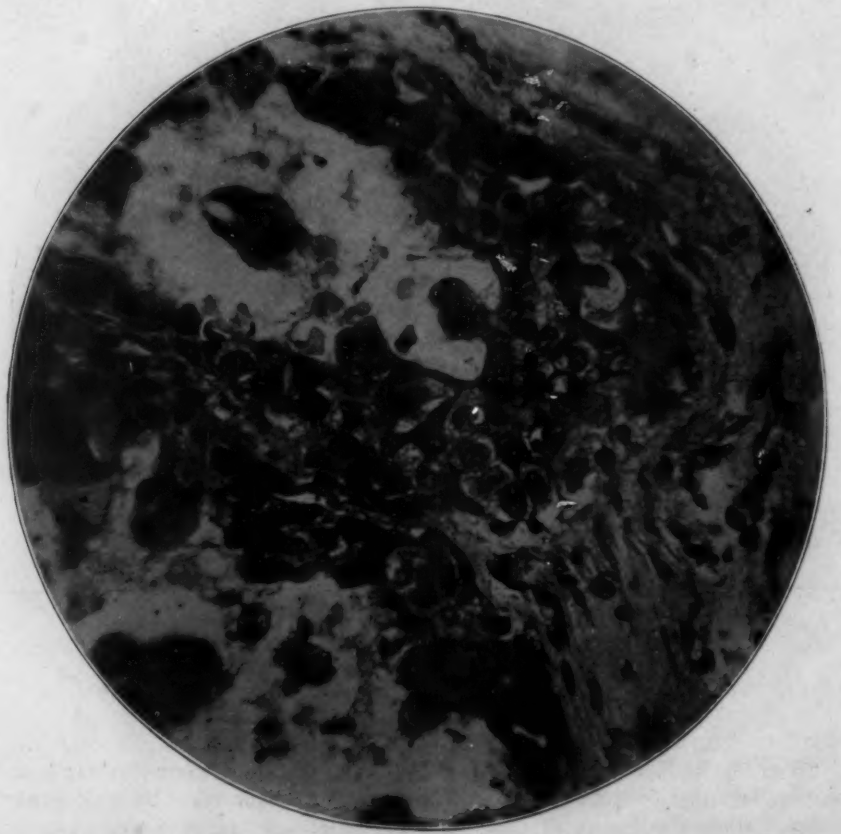

Fig. 75 (Path. No. 12451. BB-13-7 [B-CC]).—High power magnification of area shown in Figure 74. See page 525.

This patient presented the clinical picture of a benign lesion. In the first place, there were multiple tumors of both breasts of thirty-five years' duration in a woman, aged 55. These tumors had remained unchanged during lactation. The multiple tumors in the left breast were distinctly benign, and some gave the sensation of crepitation, due to calcification. One of the multiple tumors in the right breast in the upper and outer quadrant had shown growth during the

last six months, and the skin over it had become bluish. This tumor was diagnosed clinically cancer, and the complete operation performed without exploration. One of the multiple tumors of the left breast was excised and showed calcification.

Here we have the evidence that a benign tumor, one of multiple tumors, may grow after years of quiescence and give the clinical picture of a malignant tumor. Up to the present time, we have never seen cancer develop in one of multiple fibroadenomas. Billroth in his book pictures such an instance.

Fig. 76 (Path. No. 5221. BB-13-8 [CC]).—Papillary cystadenoma; in places basement membrane destroyed; arrangement of basal cells abnormal. Section from a breast, the seat of diffuse nonencapsulated cystic adenoma. For gross appearance, see Figure 25. The original diagnosis in this case was adenocarcinoma in Schimmelbusch's disease. See page 531.

Path. No. 1147. I assisted Dr. Halsted in exploring this tumor in 1895. It presented a small area of induration near the nipple. My original description records an infiltrating tumor about a nonencapsulated cystic adenoma, the size of a ten-cent piece. The center of the tumor contained a few cysts, gray-granular

alveoli in fibrous trabeculae from which semifluid material could be expressed. The infiltrating area about this resembled cancer of the scirrhous type, and sections from this area show scirrhous carcinoma (Figs. 86 and 87). As already noted, this is the only one among the eighteen cases of nonencapsulated cystic adenoma which presented the microscopic picture of cancer.

This patient was well (1921), twenty-six years after the complete operation. The glands in the axilla showed no metastasis.

Fig. 77 (Path. No. 1210. BB-13-7 [CC]).—Area of papillary cystadenoma; basement membrane in places destroyed; basal-cell arrangement abnormal. Section from a nonencapsulated cystic adenoma. For gross appearance and clinical history, see Figure 22; also see page 513.

This is a very important observation, and should make one suspicious of nonencapsulated tumors resembling cystic adenoma. But it is important to note that we recognized the malignancy in the gross at the exploratory incision and confirmed the diagnosis under the microscope.

Path. No. 1210 has been described (Figs. 22 and 77, page 513).

Path. No. 1734. I assisted Dr. Halsted also in exploring this tumor in 1897. The tumor was clinically benign, and at operation, it was looked on as a nonencapsulated cystic adenoma, composed chiefly of minute cysts containing brown-gray material and some milky fluid. At first, only the tumor was removed; then, after microscopic study with the diagnosis of adenocarcinoma, the complete operation was performed, one month later. The glands showed no metastasis. This patient was followed sixteen years until 1913, and there was no evidence of recurrence.

For microscopic pictures, see Figures 60 and 64.

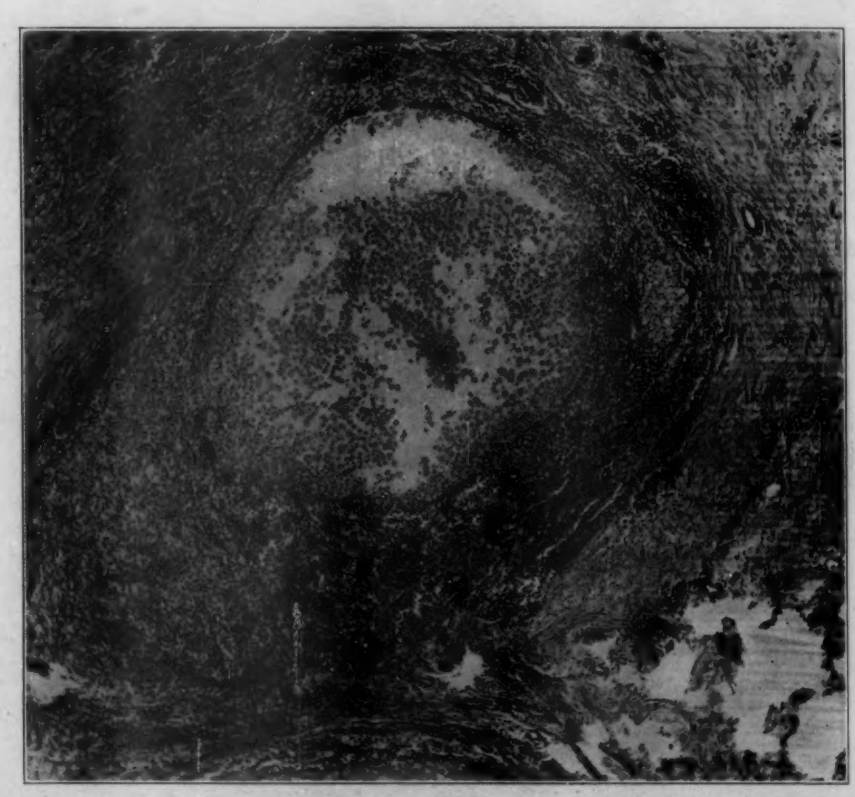

Fig. 78 (Path. No. 21192. BB-13-6 [B]).—Section of dilated duct filled with proliferating and degenerating cells, surrounded by periductal mastitis, from a breast, the seat of diffuse dilatation of ducts outside the nipple area. For gross appearance, see Figure 19, also page 511.

Path. No. 2145. In 1898, Dr. Finney at the Union Protestant Hospital performed the complete operation for cancer without exploratory incision, and sent the specimen to me. My description was as follows: "Palpable tumor in the upper and outer quadrant the size of a twenty-five-cent piece, nodular; clinically benign; on section the tumor was a nonencapsulated area of minute cysts containing brownish fluid surrounded by dense fibrous tissue." My diagnosis then, from the gross and microscopic study, was a benign nonencap-

sulated cystic adenoma. The sections show cystic adenoma, large solid adenoma similar to Figure 60 and irregular stellate adenoma in fibrous tissue (Fig. 80). The glands showed no metastasis, and this patient is well (1921), twenty-three years after operation.

Path. No. 3842. In 1901, Dr. Mitchell, then resident surgeon of Johns Hopkins Hospital, excised a tumor from the right breast of this patient, which I described as follows: "The tumor is the size of a fifty-cent piece and is composed of many minute cysts containing milky fluid." Gross diagnosis: Nonencapsulated cystic adenoma. The microscopic sections showed all the stages

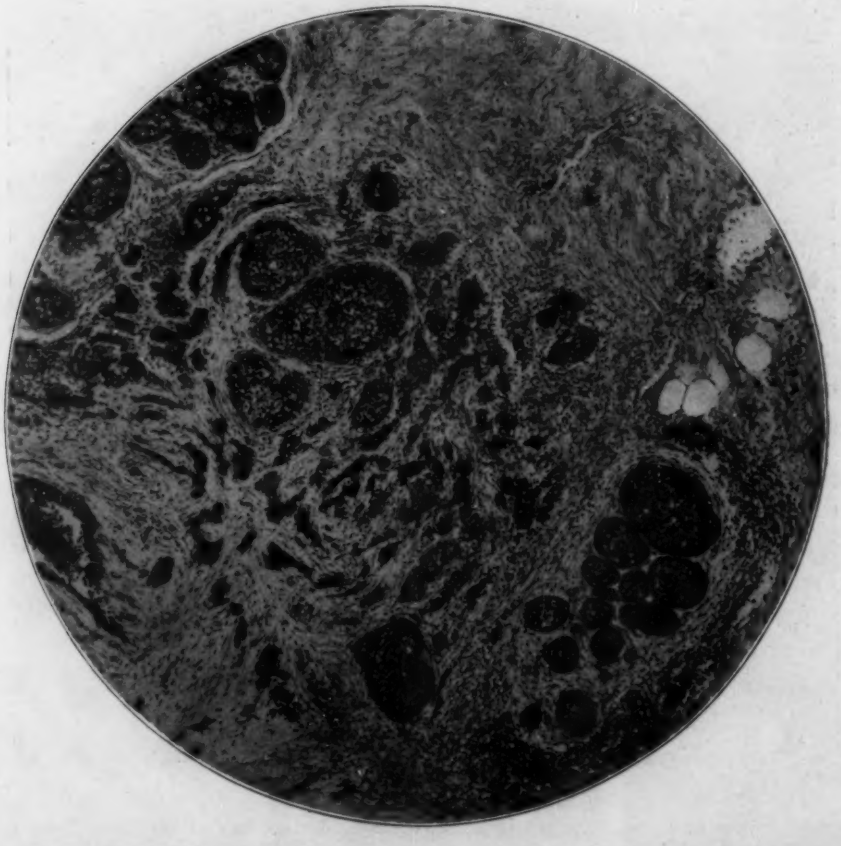

Figure 79 (Path. No. 21371. BB-13-7 [Expl. CC]).—Section of breast showing area of large solid duct adenoma and small irregular stellate adenoma. From a nonencapsulated cystic adenoma, diagnosed doubtful at exploration. Cancer operation; no metastasis to glands. Result (1921): Well, four years later. See page 524.

of chronic cystic mastitis, illustrated in this paper. Therefore, Mitchell was the only surgeon who removed only the tumor in this group of cases. Clinically, there were multiple tumors in both breasts; each breast had one distinct tumor, and, in addition, there were multiple shotlike nodules in both breasts.

Two years later, the patient wrote that another surgeon had removed the other breast. Since this date we have been unable to follow this patient.

In my opinion this is an example of multiple cystic adenoma.

Path. No. 8068. In 1907, Dr. Halsted explored this tumor, diagnosed it colloid cancer, and performed the complete operation. Dr. Porter, in the laboratory, described the gross appearance as follows: "A small, circumscribed, nonencapsulated area with many minute cysts containing drops of fluid with granular alveoli between the minute cysts." His gross diagnosis was nonencapsulated cystic adenoma with a possibility of early cancer. My microscopic description was as follows: "The tumor is chiefly a papillary cystadenoma

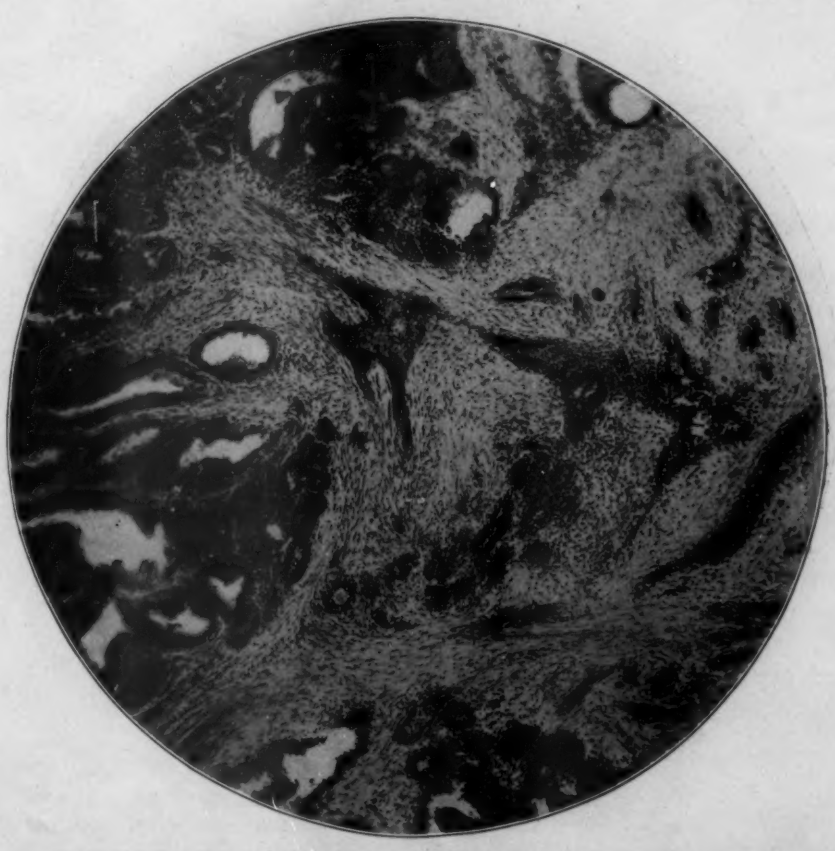

Fig. 80 (Path. No. 2145. BB-13-7 [CC]).—Area of small irregular stellate solid adenoma; basement membrane in places destroyed; basal-cell arrangement abnormal, but cells not of the cancer type. Other lobules show chiefly cystic adenoma. The glands showed no metastasis. Result (1921): Well, twenty-three years after the complete operation for cancer. See page 521.

with small epithelium-lined cysts and many adenomatous areas of different types. Diagnosis: Benign, nonencapsulated cystic adenoma." The glands showed no metastasis. This patient was well (1921), sixteen years later.

Path. No. 17012. This has been discussed (Figs. 21 and 90, page 515). In this case, I diagnosed the tumor as cancer at exploration.

Path. No. 21371. In 1917, Dr. Finney at the Women's Hospital explored this tumor, removed the breast and, after careful gross examination, performed the complete operation for cancer. When I received the specimen, it was much cut up, but I could recognize a nonencapsulated tumor, the size of a twenty-five-cent piece containing a few minute cysts buried in granular white tissue. This tumor, therefore, resembles Figure 21, except that it contained a few cysts. Its gross appearance was very suggestive of malignancy. The most suspicious area of the tumor is shown in Figure 79. The glands showed no metastasis. This patient was well (1921), four years after operation.

Fig. 81 (Path. No. 14094. BB-13-7 [T-CC]).—Area of solid large adenoma; basement membrane in places destroyed; basal-cell arrangement abnormal. For high power magnification, see Figure 82, in which the irregular cells are somewhat of the cancer type. The tumor was a nonencapsulated cystic adenoma. After removal and microscopic examination, the complete operation for cancer was performed in twenty-four hours; there was no metastasis to the glands. Result (1921): Well, eight years later. See page 525.

Therefore, among the eighteen patients with nonencapsulated cystic adenoma, nine, or 50 per cent., have been operated on by Dr. Halsted or his associates in his clinic; only one, or about 10 per cent., has shown

microscopically fully developed cancer. All but one were immediately or ultimately subjected to the complete operation for cancer. Up to the present time, all are well.

Nine cases, therefore, may be considered the proper proportion of this type in one large clinic in thirty years.

During the same period, nine specimens were sent to me for diagnosis, and they came from nine different surgeons in nine different

Fig. 82 (Path. No. 14094. BB-13-7 [T-CC]).—High power magnification of area shown in Figure 81. Area of small, irregular stellate adenoma; basement membrane destroyed; arrangement of basal cells abnormal; cells of the cancer type. See page 525.

states, demonstrating that the lesion is rare, excites interest, and pathologists disagree as to the diagnosis or benignity or malignancy. All of these patients were immediately or ultimately subjected to the complete operation for cancer. In none did the glands show metastasis. All have been followed, and none have had a recurrence or have died of cancer.

Photomicrographs of some of these cases are reproduced herewith (Figs. 53, 58, 59, 70, 74 and 81).

I am confident that it is this group of tumors that has given rise to the impression that it is not dangerous to excise a malignant tumor of the breast, submit it to microscopic study and then perform the complete operation for cancer some days or weeks later.

This type of tumor, when diagnosed adenocarcinoma, increases the percentage of cures of cancer, not only in this group, but the total

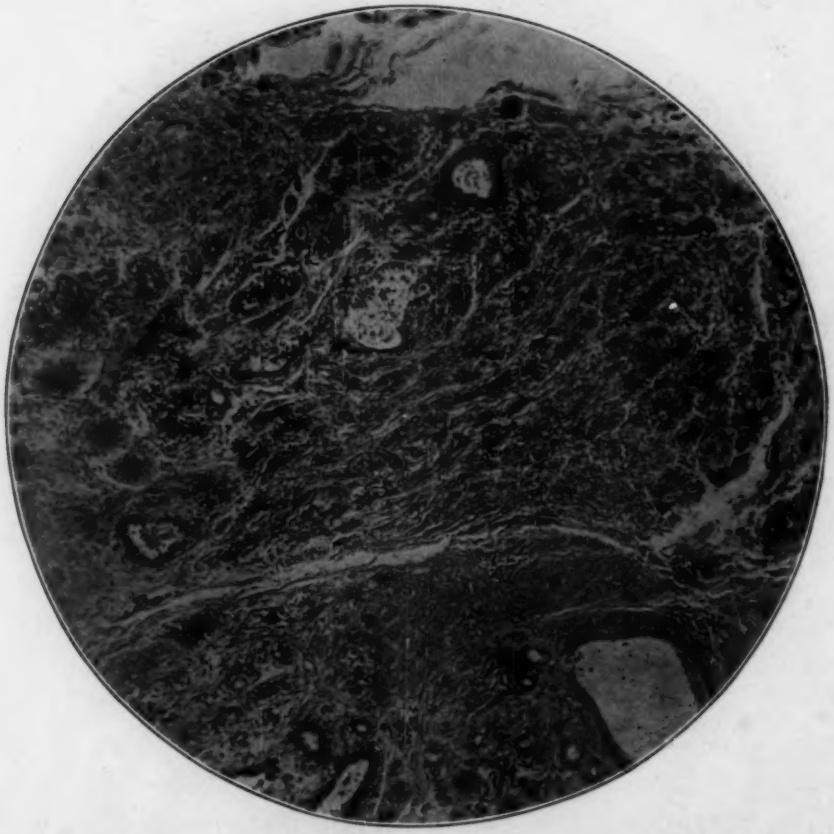

Fig. 83 (Path. No. 3965. BB-13-8 [B]).—Area of small irregular adenoma; basement membrane in places destroyed; basal-cell arrangement abnormal; cells of the basal, or resting, type; not of the cancer type. Section from breast, the seat of diffuse nonencapsulated cystic adenoma. For gross appearance, see Figure 23; for other microscopic area, see Figure 54; also see page 530.

percentage of operative cures of cancer of the breast. When these cases and some of those in group BB-13-8 were included in our cases of cancer of the breast, they increased the percentage of five-year cures. For example, when we considered all cancer of the breast without

metastasis to the glands and included these two groups with the comedo-adenoma, the percentage of five-year cures was more than 80; when we exclude these three groups, the percentage drops to 60.

Is There Such a Tumor As Adenocarcinoma of the Breast?—This intensive restudy has almost convinced me that there may be no such thing as adenocarcinoma. The malignant tumor should be called *carcinoma and adenoma.* I have shown here, among eighteen cases of non-encapsulated cystic adenoma, one with microscopic evidence of fully

Fig. 84 (Path. No. 12586. BB-13-8 [CC]).—Area of small solid adenoma; basement membrane in places apparently destroyed; arrangement of basal cells in areas abnormal, but cells of the resting basal type; some areas of cystic adenoma and dilated ducts. For clinical picture, see Figure 29; for high power magnification, see Figure 85; also see page 534.

developed cancer. This case should be diagnosed *scirrhous carcinoma and cystic adenoma.* The remaining seventeen cases belong to the group of benign nonencapsulated cystic adenoma. Yet all these seventeen cases have been diagnosed adenocarcinoma by one or more pathologists.

The same is true of BB-13-8, the diffuse nonencapsulated cystic adenoma. Of the thirteen cases, there is microscopic evidence of cancer in only one (Fig. 88), and this patient is dead of cancer. Yet, in the remaining twelve cases, one or more pathologists have made the diagnosis of adenocarcinoma in Schimmelbusch's disease.

I have, therefore, taken from our list of cured cases of cancer twenty-nine cases and placed them in the benign group. I am now restudying the cases heretofore diagnosed as adenocarcinoma-comedo and adenocarcinoma in intracystic papilloma, and I am confident that I will find in these two groups many cases that are not malignant. I must reserve this, however, for another paper.

DIFFUSE NONENCAPSULATED CYSTIC ADENOMA, KNOWN IN THE LITERATURE AS SCHIMMELBUSCH'S OR RÉCLUS'S DISEASE, OR SENILE PARENCHYMATOUS HYPERTROPHY (BLOODGOOD), OR DIFFUSE PAPILLARY CYSTADENOMA. BB-13-8, THIRTEEN CASES

For the gross appearance, see Figures 23 to 29; for the microscopic appearance, see Figures 39, 54, 56, 57, 61, 76, 83, 84 and 88.

Dr. William Welch, Professor of Pathology at Johns Hopkins, made a clear gross and microscopic description of this breast lesion in 1892.

Path. No. 227. In 1892, Dr. Halsted performed the complete operation for cancer on this patient. The glands showed no metastasis, and the patient is well (1921), twenty-nine years later. The clinical description made at that time corresponds to that found in all subsequent cases. It is as follows: "More than one half of the left breast is indurated, and the nipple is slightly retracted." Gross pathologic description by Dr. Welch: "Nipple not retracted; one half of the breast is filled with minute cysts and dilated ducts from which material can be expressed; about these ducts and cysts there is firm, granular tissue in which there are no white points or dots. The tissue cuts smoothly and not like cancer." Microscopic description by Dr. Welch: "Alveoli of cells and dense connective tissue with inflammation; the alveoli are lined by large epithelial cells which fill the alveoli with masses of cells and papilloma; other areas, smaller, are filled with solid epithelial cells. Diagnosis: Adenocarcinoma."

Here we have described papillary cystadenoma and solid duct adenoma. There is no note on the glands; no tissue or section have been preserved.

This patient was 42 years of age, and the tumor had been observed four months.

I described this lesion in 1899.

Path. No. 2660. The patient was a white woman, aged 43. The tumor had been present in the left breast nine months. It involved a quadrant, and one could palpate, in the indurated area, one large (1 cm.) and many shotlike nodules. At the exploration, I exposed a small blue-domed cyst, with clear

contents and smooth wall. On dividing the breast to remove this cyst, I found that it was diffusely involved, with other minute cysts containing clear fluid and granular material. There were also dilated ducts filled with pastil material. Recognizing the diffuse condition of the lesion at that time, I removed the breast. The microscopic picture of this case was reproduced in my chapter on Diseases of the Female Breast in Kelly and Noble's "Abdominal Surgery," Chapter 31, page 205, Figure 455, showing the areas of papillary cystadenoma with cystic adenoma. This patient was followed ten years, and there was no recurrence.

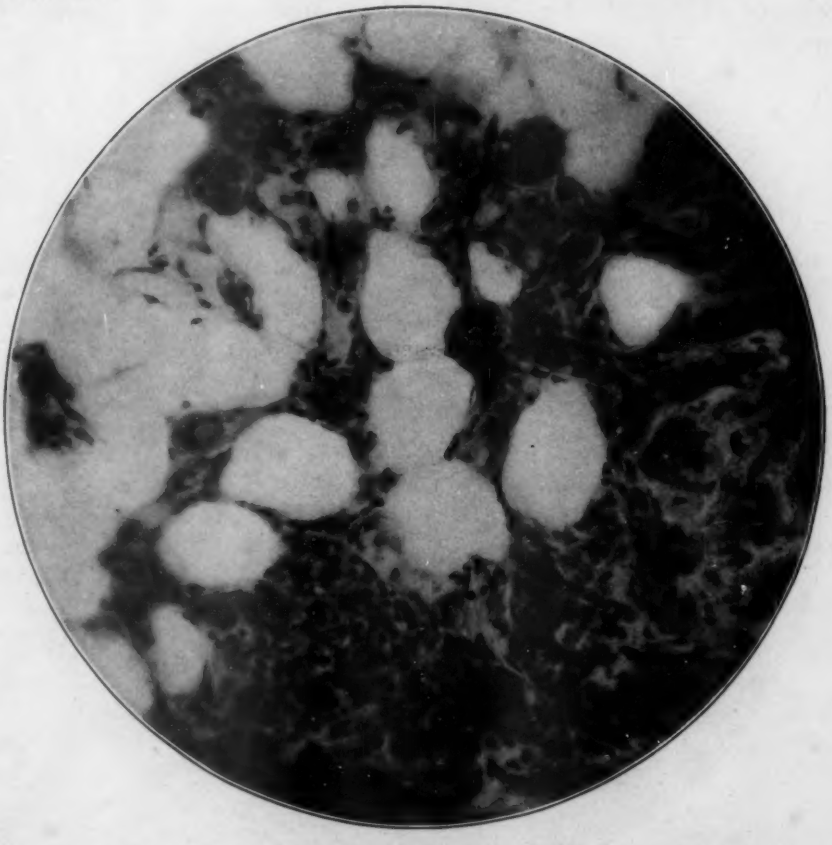

Fig. 85 (Path. No. 12586. BB-13-8 [CC]).—High power magnification of area shown in Figure 84. Small solid adenomas are apparently infiltrating the surrounding fat; but the cells are not of the cancer type. See page 534.

The third patient was operated on by Finney (1901), in Johns Hopkins Hospital. The specimen was painted by Horn (Fig. 23), and described in the gross and microscopic appearance by me.

All of us, at this time (1901), believed that we had observed a distinct clinical entity, with a chraacteristic gross appearance. It was not until later that I found that Dr. Welch had described it in 1892, whereas

I had described it in 1899. The painting of Finney's case (Path. No. 3965) is reproduced in colors in my chapter on Lesions of the Female Breast (Kelly and Noble's "Abdominal Surgery," Plate I, Figure 1), and is called there the adenocystic type of senile parenchymatous hypertrophy. I reproduced this picture again in 1917 (Lesions of the Female Breast, Binney's "Regional Surgery," p. 606, Figure 339) under the title "Chronic Cystic Mastitis, No Large Cysts."

Path. No. 3965. BB-13-8 (B). For the gross appearance, see Figures 23 and 24; for the microscopic appearance see Figures 54 and 83.

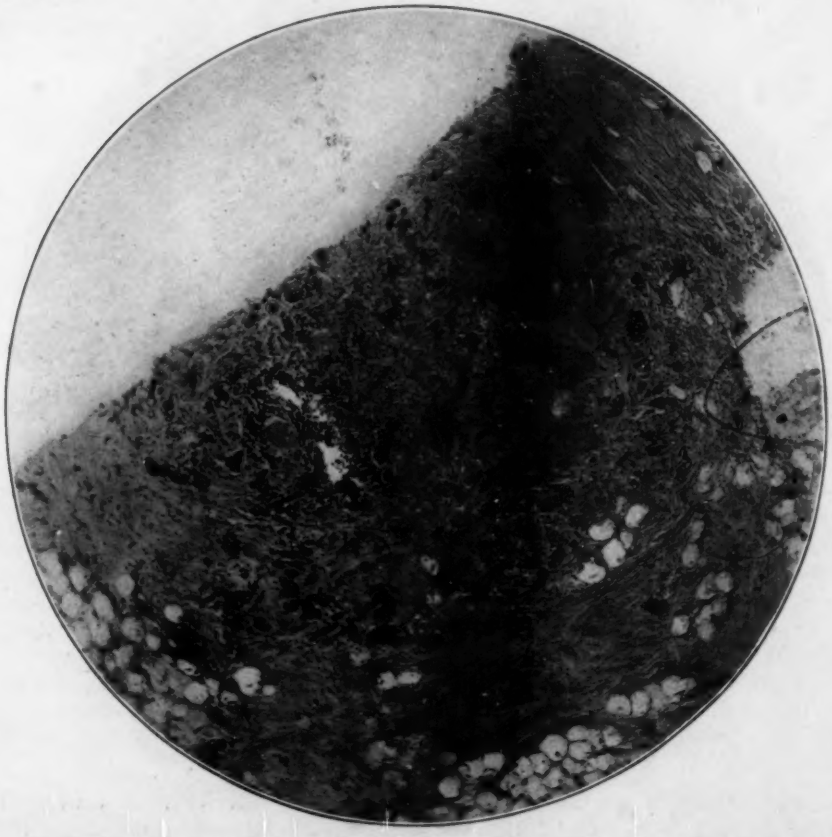

Fig. 86 (Path. No. 1147. BC-3; BB-13-7 [Expl. CC]).—Section of an area of scirrhous carcinoma in a nonencapsulated cystic adenoma. For high power magnification, see Figure 87. The malignant area was recognized by Dr. Halsted in 1895. There was no metastasis to the glands in the axilla. Result (1921): Well, twenty-six years after the complete operation for cancer. See page 520.

The clinical picture was typical. On inspection the outer hemisphere of the right breast was larger. On palpation it was felt to be indurated, like a "caked" breast. The involved area had a distinct

edge, and many shotlike nodules were felt. A brownish discharge could be expressed from the nipple.

The patient was a white, unmarried woman, aged 40. She had had pain for six months, and an enlargement for four months.

The patient would allow only removal of the breast. For the gross appearance, see Figures 23 and 24. The most suspicious areas under the microscope were those shown in Figures 54 and 83. The area from which they were taken had but 1 mm. of pectoral fascia separating it from the tissue left behind.

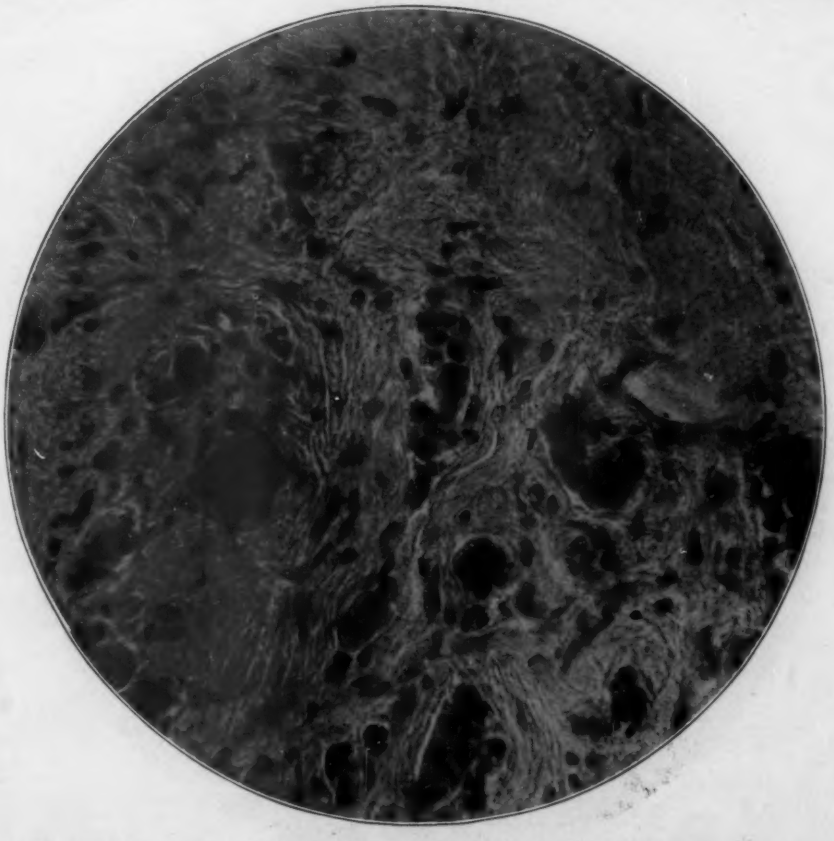

Fig. 87 (Path. No. 1147. BC-3; BB-13-7 [Expl. CC]).—High power magnification of area shown in Figure 86, scirrhous carcinoma. The nests of irregular cells are of the cancer type. See page 520.

Nineteen years later, there had been no recurrence, but the remaining breast had been removed by another surgeon in 1920. I have been unable to obtain tissue for microscopic study.

Path. No. 5221. BB-13-8 (CC). For the gross appearance, see Figure 25; for the microscopic appearance, Figure 76. The tissue in this case was brought to the laboratory in 1904 by a fourth-year student. We were informed that the patient was 47 years of age, and had had an enlargement of one breast,

involving a hemisphere, for four months. The operator first excised the breast, and then, after microscopic study with the diagnosis of cancer, performed the complete operation for cancer.

This patient was well (1921), seventeen years later. No glands were sent for microscopic study.

Path. No. 7898. BB-13-8 (B). In 1907, I received a breast specimen from Dr. Crile's clinic in Cleveland, with the typical clinical, gross and microscopic appearance of this disease; but I have been unable to obtain the result. One of my former students, Dr. Cole, who was in Dr. Crile's clinic at that time, recognized the type, and, knowing my interest, sent the specimen to me.

Fig. 88 (Path. No. 14115. BC-4; BB-13-8 [CC]).—An area of scirrhous carcinoma and an area of aberrant or irregular adenoma in a breast, the seat of diffuse, nonencapsulated cystic adenoma. For high power magnification, see Figure 89, for gross appearance, see Figure 28; also see page 537.

Path. No. 11125. BB-13-8 (CC). For the gross appearance, see Figures 30 and 31.

This was the third case to come under my observation. The clinical picture (Fig. 30) suggests malignancy, because over the prominent lump in the midzone of the upper and inner quadrant the skin was red and infiltrated.

Both nipples were congenitally depressed. The patient, however, had been aware of trouble in the left breast only two weeks. She was an unmarried white woman, aged 45, still menstruating. First, she had observed pain, then a lump. The redness did not appear until after the application of ice. Today, I think, I would interpret this history as an infection in a benign lesion and not as cancer (see Figs. 20*a* and 20*b* for a similar infection in a benign breast lesion).

The affected breast looked larger; there was bulging in the upper and inner quadrant as shown in the illustration. About the visible lump, this entire

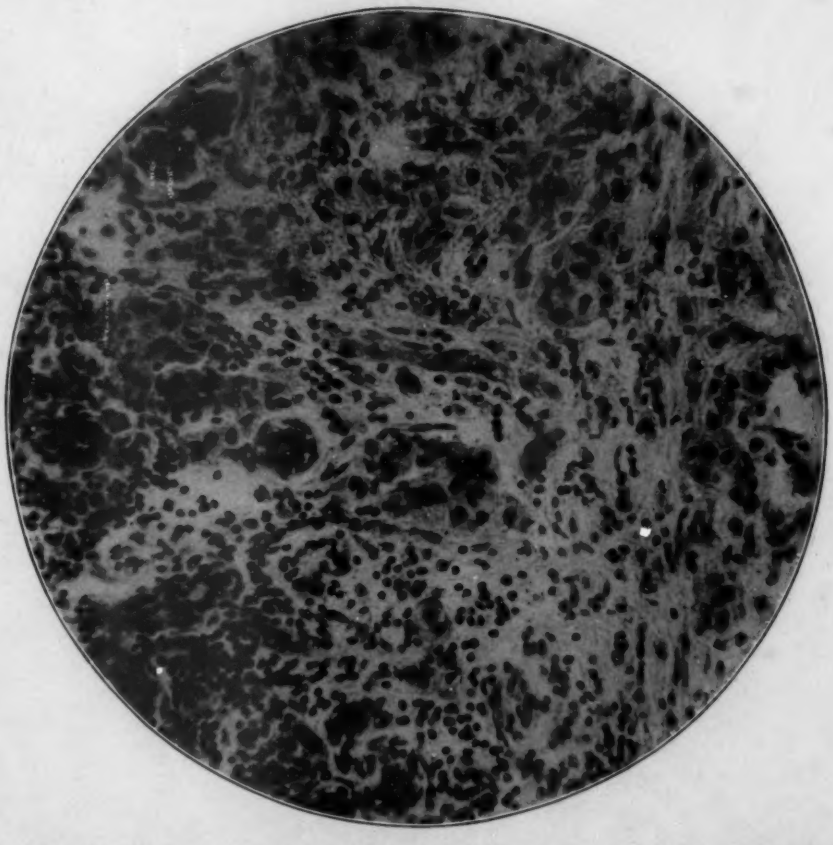

Fig. 89 (Path. No. 14115. BC-4; BB-13-8 [CC]).—High power magnification of area shown in Figure 88. The irregular nests of cells are of the cancer type, in strong contrast to the morphology and arrangement of the irregular adenomatous areas, some of the small adenoma type. See page 537.

quadrant felt like a caked breast and had a distinct edge; the red skin was infiltrated and dimpled when the breast was pushed forward. I am of the opinion today, ten years later, that I could recognize this clinically as an infection in nonencapsulated diffuse cystic adenoma. However, at that time, I performed the complete operation for cancer.

Gross Pathology.—Figure 30 is a reproduction of the painting from the fresh specimen. There are two cysts; the one to the right is infected, the one to the left, marked with the dissecting forceps, is a blue-domed cyst. More than one half of the breast is enlarged by increased connective tissue and riddled with minute cysts and dilated ducts, from which could be expressed a varicolored pastil material.

The microscopic sections show all the stages of chronic cystic mastitis. Papillary cystadenoma and epithelium-lined cysts predominate. The infected cyst is lined by granulation tissue, and the breast about it is the seat of mastitis.

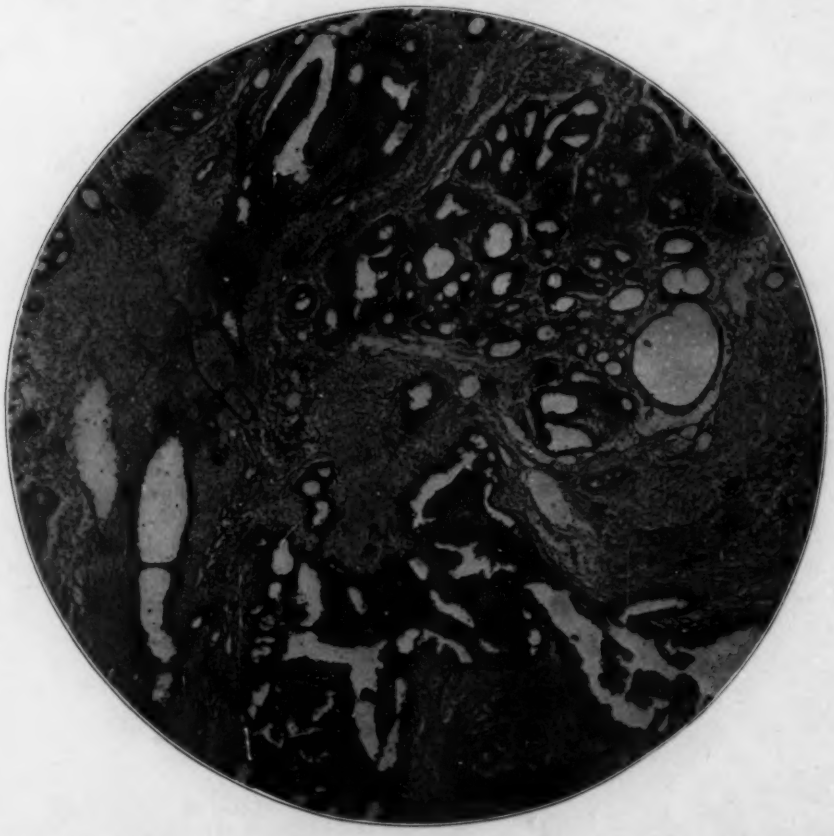

Fig. 90 (Path. No. 17012. BB-13-7 [Expl. CC]).—Section of nonencapsulated cystic adenoma. For gross appearance, see Figure 21. Areas of cystic adenoma, a few areas of papillary cystadenoma, some solid duct adenoma. For high power magnification, see Figure 91; also page 515.

Result (1921).—After ten years the patient is well.

Path. No. 12586. BB-13-8 (CC). Figure 29 is the reproduction of a photograph of the patient; photomicrographs are shown in Figures 84 and 85.

Clinical Note.—This patient was observed by me in 1912, and represents a variation in the clinical picture which we have observed once since, that is,

intermittent retraction of the nipple as a symptom of onset, with the induration of the breast chiefly in the nipple and areolar zone. This patient, a white unmarried woman, aged 38, had observed intermittent retraction of the left nipple for four years, and permanent retraction for four months, while she had observed intermittent retraction of the right nipple for four months. On inspection, both nipples were retracted; on palpation, the left nipple remained retracted, while the right nipple bulged. There was indefinite induration beneath both nipples. I first performed the complete operation on the left breast, and then, three weeks later, removed the right breast, and then, six

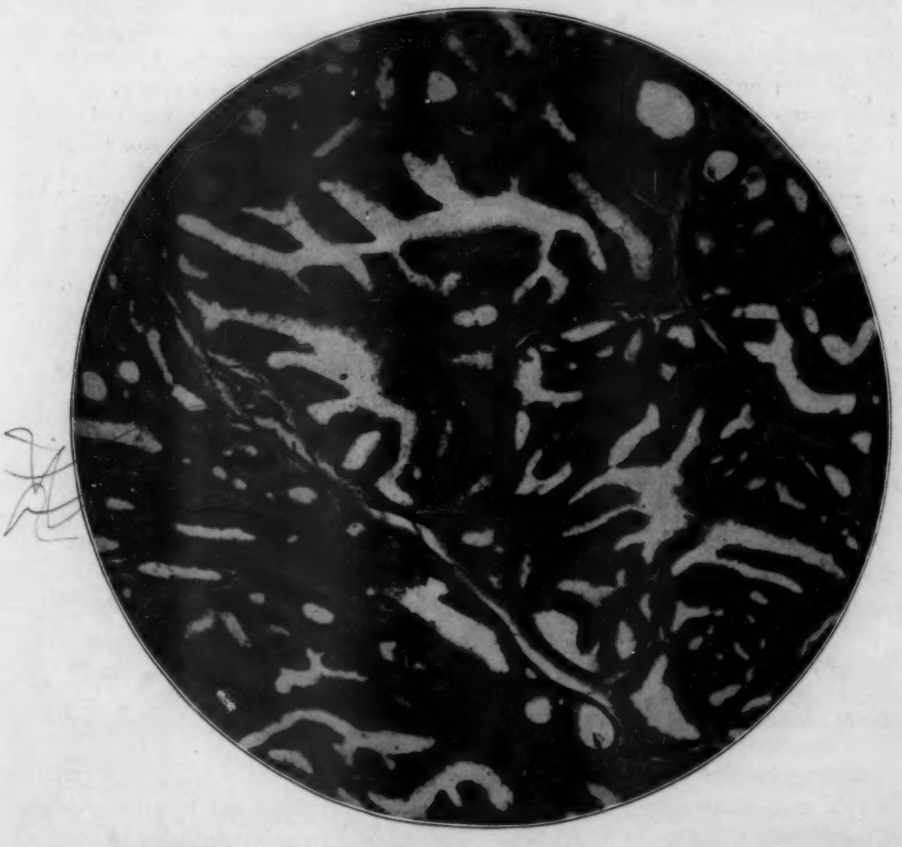

Fig. 91 (Path. No. 17012. BB-13-7 [Expl. -CC]).—Section from nonencapsulated cystic adenoma. For gross appearance, see Figure 21; for other microscopic area, Figure 90. This area is a papillary cystadenoma somewhat resembling lactation hypertrophy. See page 515.

months later, removed the glands in the right axilla. The operation on the right side was an illogical one; but at my first pathologic examination, I interpreted this case as adenocarcinoma in chronic cystic mastitis.

This patient is well in 1921, nine years later.

Pathology.—In an infiltrating zone beneath both nipples there was an area of nonencapsulated cystic adenoma. The surrounding breast was senile and

fatty. The most prominent histologic picture was solid small adenoma, and I venture to describe the picture in Figure 84 as the "flower pot" lobule. These small, solid adenomas infiltrated the fat (Fig. 85).

Path. No. 13204. BB-13-8 (Expl. CC). For the microscopic picture, see Figure 61.

Clinical Note.—This patient also had had intermittent retraction of the nipple of eighteen months' duration when she was observed by Dr. Heuer, in 1912. At the examination, the retraction of the nipple was permanent. The patient was a widow, aged 49. She had observed the nipple of the left breast to pull in and then protrude, off and on for eighteen months. There had been no discharge from the nipple. She sought advice because of pain of four months' duration. On palpation, nothing very definite was made out. Dr. Heuer explored and was of the opinion that the breast beneath the nipple was the seat of cancer. He immediately performed the complete operation. The breast, when received in the laboratory, had been much cut up, but I found, similar to Path. No. 12586 (Fig. 29), a zone of nonencapsulated cystic adenoma beneath the nipple. The surrounding breast was fatty and senile. The most suspicious microscopic areas are shown in Figure 61—small, irregular stellate solid adenoma with some cystic adenoma. The glands showed no metastasis.

Result.—This patient returned two years later with a similar clinical picture in the right breast—intermittent retraction of the nipple of one year's duration, permanent retraction for the last three months. On palpation, indefinite lumps were discovered in this breast. Dr. McClure, the resident surgeon at Johns Hopkins, because the diagnosis of adenocarcinoma in chronic cystic mastitis was still unchanged, performed the complete operation for cancer. The gross and microscopic pathology of this breast was practically identical with that in the breast removed at the first operation.

This, therefore, is our second observation of intermittent retraction of the nipple as a symptom of onset of this form of chronic cystic mastitis. In both cases, ultimately both breasts were involved.

Path. No. 16431. BB-13-8 (CC). I received sections from this breast from an outside source. It had been diagnosed clinically as cancer, and the complete operation was performed. There has been no recurrence in 1921, seven years later.

Path. No. 20457. BB-13-8 (CC). For the microscopic picture, see Figure 57.

This case is interesting because the left breast had been subjected to the complete operation for cancer by me in 1914. The lesion proved to be diffuse comedo-adenoma with no areas of cancer and no metastasis to glands.

I removed the right breast in 1916, two years later, because of pain and an indefinite nodule beneath the nipple. At that time I was still calling diffuse comedo-adenoma, adenocarcinoma; and, in view of the fact that a woman who had been operated on for malignant tumor of one breast runs a greater risk of cancer (almost 10 per cent. more) in the other breast, I removed the latter. Its gross pathology was that of diffuse nonencapsulated cystic adenoma, and the predominant histologic picture was papillary cystadenoma in the ducts (Fig. 57).

This patient was well (1921), seven years after the first operation.

Path. No. 26046. BB-13-8 (BB). For the gross appearance, see Figure 27; for the microscopic appearance, see Figures 39, 40, 41 and 42.

Clinical Note.—This was my first observation of the lesion involving both breasts without retraction of the nipples. The entire breast was involved, and each presented the identical sensation to palpation. One could palpate the edge of each breast throughout its circumference. The entire breast was indurated as in mastitis, with some shotlike nodules. The nipples were not retracted. The patient was a white unmarried woman, aged 43, still menstruating. She asserted that both breasts had been lumpy for years. During the last month, the lumps had become larger and had fused, so that now she could not pick out a single lump. There had been pain in both breasts for two weeks.

I made the clinical diagnosis of this type of chronic cystic mastitis and removed both breasts.

The gross pathology (Fig. 27) is the same in both breasts, and resembles closely that shown in Figure 23.

The predominant histologic picture is minute cysts, cystic adenoma and small solid adenoma (Figs. 39, 40, 41 and 42).

Result (1921).—One year later the patient was well.

Path. No. 26439. BB-13-8 (CC). For the gross appearance, see Figure 26; for the microscopic appearance, Figure 56.

I examined this patient with my colleague Dr. Seegar at St. Agnes Hospital in July, 1920. The lesion completely involved one breast only. The nipple was not retracted, nor had there been discharge from it. I advised the complete operation, which was performed. The gross pathology (Fig. 26) was a little unusual—minute cysts and dilated ducts with yellow and green material were not so prominent a feature as in Figures 23 and 27; but the surface of the breast presented small irregular, granular alveoli, as described by Welch in 1892 (p. 528) and the predominant microscopic picture was papillary cystadenoma in ducts (Fig. 56).

CANCER AND DIFFUSE NONENCAPSULATED CYSTIC ADENOMA

Path. No. 14115. BC-4 and BB-13-8 (CC). For the gross appearance, see Figure 28; for the microscopic appearance, see Figures 88 and 89.

Clinical Note.—In 1913, Dr. Finney at Union Protestant Hospital performed the complete operation for cancer on this patient and sent the specimen to my laboratory. It was his opinion that clinically and in the gross the disease was cancer. The history sent with the specimen was very brief: "White, unmarried female, aged 39; symptom of onset enlarged glands in the axilla eleven months; lump in the affected left breast, one month; lump in the right breast, one month." A gross section of the breast is shown in Figure 28. When I examined this breast, the palpation was typical of this form of chronic cystic mastitis. The entire breast was involved, indurated, with many minute shotlike nodules; but portions of the breast felt almost as hard as cancer. On section, there were a few minute cysts and dilated ducts; but the most marked feature was increased fibrous stroma with granular alveoli, and one or two small areas which felt and looked like cancer. These areas are shown in Figures 88 and 89, and picture scirrhous carcinoma and an area of aberrant or irregular adenoma. The axillary glands showed metastasis. Other areas of the breast showed a few epithelium-lined cysts and dilated ducts, cystic adenoma, irregular adenoma, aberrant adenoma.

Result.—Death occurred in ten months from metastasis to the brain. There was local recurrence in the scar before death.

Comment.—Enlarged glands in the axilla as the symptom of onset in cancer of the breast are a very rare observation. I cannot recollect more than three cases. Apparently, Dr. Finney made the diagnosis of malignancy from the palpation of these glands. It is the only case of cancer which I have had the opportunity to observe and in which the cancer was almost a microscopic area. But this case seems to show that cancer *may* develop in this type of chronic cystic mastitis, one out of thirteen cases—about 8 per cent.—while among eighteen cases of nonencapsulated cystic adenoma (BB-13-7 occurring as a small palpable tumor), there has been one example of cancer easily recognized in the gross—about 6 per cent.

Cancer and Chronic Cystic Mastitis.—I mentioned this in the beginning of my article; but I find that I have neither time nor space to describe it in detail. We have restudied all the cases of fully developed cancer in relation to the condition of the surrounding breast; but this investigation is not quite completed, so that I am unable to give the exact figures; but I am confident that when the study is finished, the conclusion will be that the predominant picture of a breast the seat of cancer is senile.

BB-12-1.—On three occasions, we have observed blue-domed cysts and some chronic cystic mastitis in a breast removed for cancer; but in these cases neither the cyst, nor the chronic cystic mastitis was made out until after the complete operation had been performed and the breast sectioned. The cyst as a tumor had never been observed by the patient.

BB-12-2.—As yet we have not found a cyst of the galactocele type associated with cancer of the breast.

BB-12-3.—We have never observed cancer in the diffuse cystic disease of the breast. This conforms to the observations of Billroth, Velpeau, and all the older authorities, which I have read with great care.

BB-13-4 and 5.—In a large number of breasts completely removed for cancer, we have noted increased parenchyma in adenomatous areas, here and there a minute cyst, or one or more dilated ducts. But this condition of the breast had presented no clinical symptoms.

BB-13-6.—The extreme degree of dilatation of the ducts beneath the nipple, presenting itself clinically as a palpable wormlike mass beneath the nipple, has never been observed in association with cancer of the breast. On a few occasions, the ducts beneath the nipple have been slightly dilated and filled with the characteristic material; but the malignant tumor has been outside this zone, and there has been nothing to palpate beneath the nipple in these cases.

BB-13-7.—I have already noted and described one case of scirrhous cancer and cystic adenoma. There have been a few more, all of which were recognized, either clinically, or in the gross, as cancer, and treated as cancer.

BB-13-8.—I have illustrated and described one case of cancer in the diffuse nonencapsulated cystic adenoma. There are a few other observations; but in all, the lesion was clinically malignant, the complete operation performed, and this type of chronic cystic mastitis found in making a gross section of the breast.

Microscopic areas which may be called chronic cystic mastitis are not uncommon findings even in the senile breast.

Among the 350 cases of chronic mastitis, my evidence seems to show that if the palpable single or multiple lesion can be recognized in the first six groups, which include 319 cases, the breast can be saved without the patient running any more risk of cancer than is incidental in any woman at the same age.

In regard to groups BB-13-7 and -8, in the small isolated and the diffuse nonencapsulated cystic adenoma, lesions easily to be differentiated from the others, it might be safer for the present to perform the complete operation for cancer.

Conservative Operation for Chronic Cystic Mastitis of the Types 1 to 6.—As a matter of fact, among the 319 patients subjected to operation in these six groups, conservative operations have only been performed in 128 cases, about 38.5 per cent. Of these 128 conservative operations, I have performed sixty-two, or 47 per cent., while my colleagues at Johns Hopkins are credited with thirty-two cases, and outside surgeons with thirty-four cases.

The most common type of chronic cystic mastitis to be subjected to the conservative operation is BB-12-1, the blue-domed cyst—ninety-three cases (Bloodgood forty-nine, more than 50 per cent.; Johns Hopkins, twenty-five; outside surgeons, nineteen).

Further discussion as to the relation of the extent of the operation to the clinical picture and pathology at exploration will be postponed for a second paper.

The present paper deals with the most important feature of the diagnosis—pathology; and I trust that it will aid operators and pathologists to recognize more frequently the types of chronic cystic mastitis.

THE MICROSCOPIC PICTURE OF THE DIFFERENT TYPES OF CHRONIC CYSTIC MASTITIS

Classification.—The following classification is based on the study of hundreds of sections and is an attempt to describe the different histologic pictures using the simplest nomenclature which had been

previously employed in the literature and textbooks. When more than one term has been used to describe apparently identical pictures, I have tried to select the one most frequently in use.

Main Division.

I. Adenomatous.
II. Cysts.
III. Dilated Ducts.
IV. Papillary Cystadenoma.
V. Solid Adenoma.
VI. Mastitis.
VII. Changes in the Basement Membrane.
VIII. Changes in the Basal-Cell Arrangement.
IX. Changes in the Morphology of the Cell.
X. Changes in the Stroma.

All the histologic pictures seen in chronic cystic mastitis and in all benign lesions of the breast can be described within these nine main divisions.

Subdivisions.

I. Adenomatous.
1. Normal (Fig. 32).
2. Lactation (Fig. 33).
3. Senile (Fig. 34).
4. Fibro-adenomatous (Fig. 35).
5. Intracanalicular (Fig. 36).
6. Aberrant (Figs. 37 and 52).
7. Irregular (Fig. 38).
8. Cystic (ectasia) (Figs. 39 and 43).

II. Cysts.
1. Large cysts, no epithelial lining (Fig. 44).
2. Large cysts, epithelial lining (Figs. 45 and 46).
3. Small cysts, epithelium-lined (Figs. 47 and 48).

III. Dilated Ducts.
1. Small dilated ducts, almost normal (Figs. 32, 35 and 37).
2. Large (Figs. 49, 50 and 78).
3. Small ducts with thickened walls, residuum from old mastitis (Fig. 34).

IV. Papillary Cystadenoma.
1. Isolated in lobule (Figs. 52 and 53)
2. Diffuse, alveolar (Figs. 55, 70, 72, 73, 74, 76, 77 and 91).
3. In ducts (Figs. 56 and 57).

V. Solid Adenoma.
1. Small alveolar (Figs. 39, 40, 58 and 63).
2. Large, apparently in ducts (Figs. 59, 60, 79, 81 and 90).
3. Small irregular stellate (Figs. 41, 61, 79 and 80).
4. Comedo (not observed in chronic cystic mastitis).

VI. Mastitis.

1. Alveolar with atrophy (Figs. 44, 62 and 67).
2. Alveolar with solid adenoma (Figs. 62 and 63).
3. Periductal (Figs. 34, 64, 65, 66 and 78).
4. Diffuse; interstitial (Fig. 67).
5. Zones of granulation tissue (Figs. 67 and 68).
6. Giant cells (Fig. 67).
7. Tubercles (none found in chronic mastitis).
8. Organized hematoma (Fig. 69).

VII. Basement Membrane Changed.

1. Intact (Figs. 32, 33, 35, 36, 39, 45, 55, 57, etc.).
2. Destroyed or atrophied, partially or completely (Figs. 42, 62, 66, 71, 73, 74, 75, 76, 77, 79, 81, 83 and 85).

VIII. Basal-Cell Arrangement.

1. Normal in all the figures noted after VII-1, basement membrane intact.
2. Abnormal in most of the figures noted after VII-2, basement membrane destroyed; most marked in 66, 75 and 82.

IX. Morphology of the Cell.

1. Basal—resting (Figs. 32, 35, 36, 38, 59, 60, 61 and 72).
2. Glandular—active (Figs. 33, 53, 54, 55, 56, 57, 74 and 82).
3. Atrophic—degenerating (Figs. 34, 62 and 79).
4. Proliferating and desquamating (Figs. 51, 56, 66, 77 and 78).
5. Suggestive of the cancer type (Figs. 76, 77 and 82).

X. Fully Developed Cancer. (Figs. 86, 87, 88 and 89).

Comment on the Microscopic Picture.—It is important to record that the histologic pictures shown in Figures 33 to 85 and in 90 and 91 have never been observed in the breast of a patient whose glands showed metastasis, or who had definite cancer. Similar microscopic pictures are to be found in the encapsulated adenoma (fibroadenoma, intracanalicular and cystic); in the intracystic papilloma, in diffuse virginal hypertrophy; in mastitis associated with lactation, unassociated with lactation, and in tuberculous mastitis.

Most of these microscopic pictures have been observed in the breast tissue surrounding a blue-domed cyst, in which the cyst and a zone of breast tissue had been removed; and yet, there has been no recurrence nor the development of cancer after many years' observation of the patients.

In the breast surrounding the blue-domed cysts, certain microscopic pictures are uncommon such as those shown in Figures 55 and 73.

Certain microscopic pictures have been observed only in BB-13-7 and -8, the isolated and diffuse nonencapsulated cystic adenoma, for example, Figures 56, 74, 76, 77; but similar pictures have been seen in the encapsulated cystic adenoma.

Characteristic Histologic Pictures.—Figure 32 shows an almost normal breast; Figure 33 is lactation hypertrophy; Figure 34 in its thick-walled ducts indicates an old mastitis of years' duration; Figure 36 is

an intracanalicular myxoma; Figure 44 is the thick wall of a large cyst; Figure 45 is typical of a duct; Figure 48 is characteristic of the diffuse cystic disease of the breast; Figure 49 of diffuse dilatation of the ducts beneath the nipple; Figure 56 is almost characteristic of the diffuse nonencapsulated cystic adenoma in which papillary cystadenoma of the duct predominates.

Where Pathologists Disagree.—I have submitted sections of every type of chronic cystic mastitis, lactation mastitis, tuberculous mastitis, encapsulated cystic adenoma, fibro-adenoma, and intracystic papillomas to more than forty consulting pathologists, and I have their written diagnoses. In the majority of these cases, there was disagreement; the percentage of those favoring benignity varied from twenty to ninety.

In all of these demonstrations, the sections illustrated in Figures 87 and 89 were included. On these two cases of fully developed cancer, there was not a single disagreement.

During the same period, many sections and tissues have been sent to me from other surgeons and pathologists with their diagnoses. I have never received one which proved to be a fully developed cancer that had not been diagnosed cancer. But I have received many with a diagnosis of cancer which in my opinion belonged to one of the above mentioned benign groups.

It is very interesting to record here again that in breast lesions, when good pathologists disagree as to malignancy, the patient lives; when there is agreement, there is always a large percentage of deaths from cancer.

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THE ACHIEVEMENTS AND LIMITATIONS OF NEUROLOGIC SURGERY*

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In my lifetime, the history of neurologic surgery has been written, and the most important events have occurred in half that time. In limiting the development of this special field to this period, I am not unfamiliar with the fact that trephination was an accepted surgical procedure years before the days of Hippocrates, the Father of Medicine, when the Egyptians trephined the skull for migraine and epilepsy, and that in the second century, Galen, whose favorite field of investigation was the nervous system, advocated sundry operations for injuries to the brain. He was familiar with the clinical picture of cord compression and recommended operation for its relief. While from Galen's time to the days of modern medicine, there have been isolated instances of operation, dealing with the nervous system, mostly for the relief of traumatic lesions, the growth and development of neurosurgery along broad lines and in an ever-widening zone of lesions did not occur until our own day; until the indications for surgical interference so multiplied as to command the attention of those who could give it their exclusive time and thought. Thus, in time, neurosurgery became recognized as a surgical specialty.

In passing so hastily from Galen's to our own time, we should not forget that Broca (1824-1880) has been acknowledged as the founder of modern surgery of the brain. Broca was the first to trephine for the evacuation of cerebral abscess, which had been diagnosed by his theory of localization of function. His discovery of the center of articulate speech—Broca's region—in the third left frontal convolution laid the foundation for cerebral localization. But I have always pictured the era of surgical neurology as beginning with the work of Sir Victor Horsley. How fortunate it was that the pioneer in this field should have embodied all qualifications that even now we conceive as ideal: he was the experimentalist, the neurologist, the surgeon, all in one. If we were to outline a course in preparation for the practice of surgical neurology, we could do no better than to use Horsley's life and activities as the prototype. His fundamental knowledge of neurology, his enthusiastic pursuits in the experimental laboratory, especially in brain localization, his ingenuity in matters of surgical technic were the foundation stones of his brilliant career.

*Read before the Iowa State Medical Society, Des Moines, May 12, 1921.

In 1886, Horsley performed the first successful operation for the removal of brain tumor, and from that time on, brain tumors have been one of the larger, if not the largest, problems of the neurologic surgeon. The mechanics of cranial exploration have been mastered; but the management of the individual case after the cranial cavity has been opened taxes the resources of the operator, and to carry it to a successful issue implies an intimate knowledge of the causes of increased intracranial pressure and the manner of dealing with them, of the sources of hemorrhage and how to control it, of the naked eye appearance of normal and pathologic brain tissue, of the limitations of surgical intervention and the recognition at the operating table of what constitutes an operable and what an inoperable lesion.

We have outlived what used to be called the "expectant treatment" of tumors, a screen behind which the physician concealed his inability to make a diagnosis. Contrary to the general impression, gummas of the brain are exceedingly uncommon. I have seen but two in my clinic, and, with the greater aids to diagnosis, there is now no excuse for that indefinite course of iodids and mercury. I hoped to outlive this practice; at least, I have lived to see it on the wane.

TYPES OF TUMORS AND THEIR TREATMENT

We have come to recognize distinctive problems in different types of tumors. There is as much difference between an endothelioma and a glioma as between a gastric ulcer and an infiltrating carcinoma of the wall of the stomach. The former are definitely encapsulated tumors, and, taking their origin from the membranes, are readily accessible except at the base of the brain. Fortunately, they have been more frequent than the gliomas in our clinic; the proportion of the endothelioma group to the glioma group has been as 6 to 4, in those cases in which the tumor has been exposed on the operating table. The size of the tumor is relatively unimportant (Fig. 1). Not only from the standpoint of operability, but of immediate mortality, must endotheliomas be considered quite apart from gliomas. In the latter, sharpness of definition is often lacking. By replacing normal brain tissue without adding to the volume of the cranial contents gliomas often grow to large dimensions before there are signs of intracranial pressure and the surgeon is consulted. (I must qualify this statement by admitting exceptions. Only within the year have I seen two tumors, grossly appearing as endotheliomas, sharply defined and encapsulated, but having the microscopic characteristics of gliomas [Fig. 2].)

To illustrate this distinction between the glioma and endothelioma I have compared the last ten cranial explorations for endothelioma with the last ten cranial explorations for glioma. In the endothelioma

series, the lesion was regarded as operable in all, and there was but one fatality. In the glioma series, but one of the ten was considered operable and five of the ten patients succumbed to the mere effects of exploration. Mere exploration in the glioma is attended with a risk peculiar to this lesion. Following the operation, an edema develops, or hemorrhage in the tumor from a ruptured blood vessel ensues. The patient, soon or immediately after the operation, may pass into a stupor, gradually deepening, until within from twenty-four to forty-eight hours the end comes (Fig. 3). One sees the brain

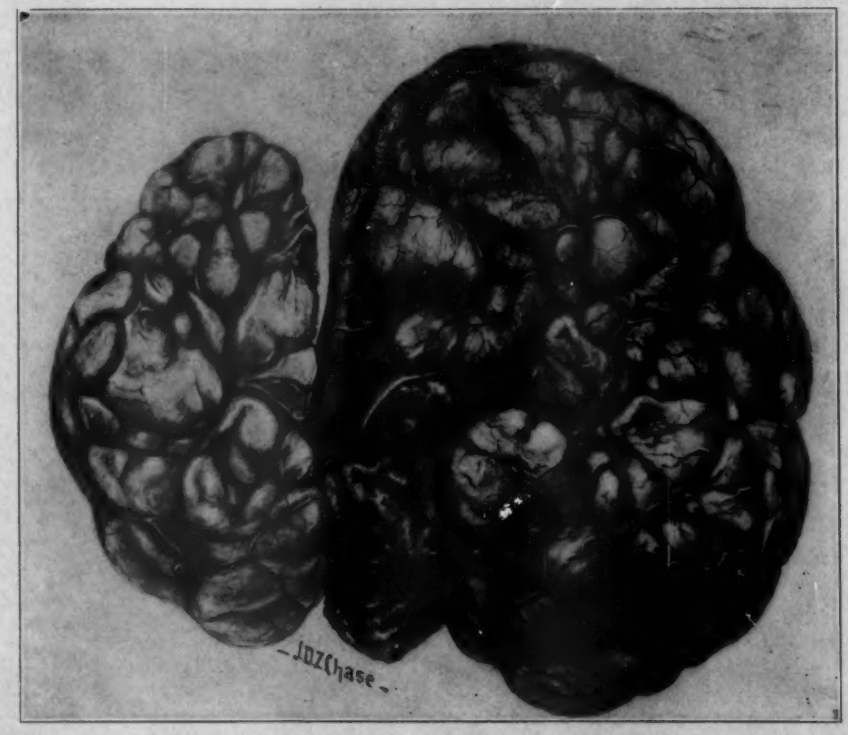

Fig. 1.—Tumor, 13 by 10 by 6 cm., after removal from frontal region of a boy, aged 6 years.

begin to swell soon after the dural flap is reflected, and it continues so to increase in bulk within the time of exploration that closure of the flap either is attended with great difficulty or is impossible. This process of edema develops in the gliomas not only when the pressure conditions are altered by reflection of an osteoplastic flap, but even by the establishment of a decompressive opening, so that one must be prepared for a fatal issue, even after an operation of itself so comparatively free from danger as the subtemporal decompression.

It is essential that one should be able at the operating table to distinguish between a lesion which may be said to be operable and one which is inoperable. It is in this connection that judgment and experience count. The tolerance of the brain to exploration, when disturbed by conditions of increased intracranial pressure, must be appreciated. The operator can learn only by experience what constitutes operability and inoperability and must be willing and ready to recognize barriers, when confronted with tumors, to successful or satisfactory extirpation. In the consideration of the surgical problems of brain tumors, a discussion in general terms is fruitless and misleading. Differences in location and differences in tumor types are such as to demand, in an intelligent discussion of relative values, whether it be in matters of diagnosis, in matters of technic or in end-results, a subdivision or classification. Such a classification should recognize as distinct neurosurgical problems: I. Pretentorial lesions:

Fig. 2.—Glioma immediately after removal, showing its encapsulation.

(*a*) endotheliomas; (*b*) gliomas, and (*c*) pituitary lesions. II. Subtentorial lesions: (*a*) pontile angle tumors; (*b*) "acoustic" tumors, and (*c*) hemispheric and intrahemispheric tumors.

A further distinction should be made in reports published under the general heading of brain tumors between those "verified" by examination of specimen removed on the operating table or at necropsy. All other cases should be considered in a group by themselves as "unverified."

PSEUDOTUMORS, SO-CALLED

I have seen in these years a group of cases, call them what you will, in which a preliminary diagnosis of tumor was made which failed to be confirmed at the operation; and yet, after the relief of pressure,

the symptoms have subsided and the subsequent course of events has eliminated the possibility of the existence of a growth. Objections have been made to the term "pseudotumor" and its recognition as a clinical entity, and quite properly; but the existence of this nondescript group, with the possibilities not only of relief from headache and vomiting and of the conservation of vision but also of complete recovery, is, to my mind, one of the strongest arguments in favor of decompressive operations. In all probability, the underlying pathologic condition in these cases simulating tumor is a meningitis or leptomeningitis. The onset is so insidious that it is difficult to determine the source of infection, but, it has been my belief that the exanthematous and infectious fevers are in many instances the responsible factors, particularly whooping-cough, measles and influenza. The case herewith reported is an instance in point:

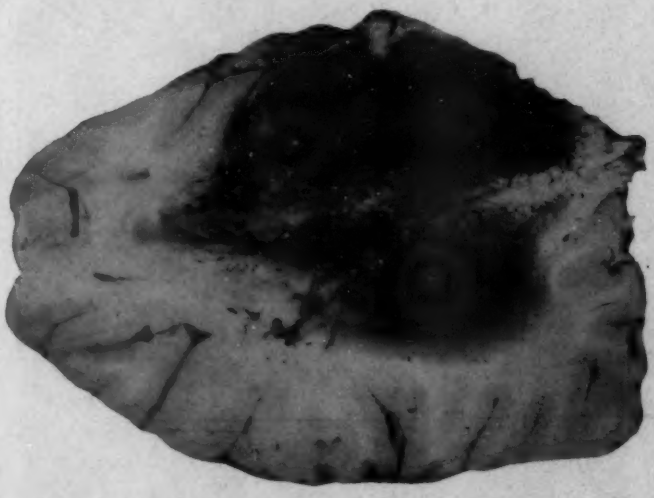

Fig. 3.—Subcortical glioma, showing vague, indefinite outline as the tumor infiltrates the surrounding tissue, a typical inoperable growth.

Case 1.—M. L. F., aged 22 years, was admitted to the Neurosurgical Service of the University Hospital, Nov. 27, 1919. She had had influenza in October, 1918. In May, 1919, she began to complain of headache, frontal and occipital, which gradually became most intense, and in October it was associated with vomiting. Later she noted tinnitus in the right ear. She was subject to attacks of vertigo, and she could not preserve her equilibrium when standing or walking. Examination of the eye grounds revealed a papilledema of + 5 diopters in each eye. A preliminary diagnosis of tumor was made; but there were not enough physical signs to warrant its localization. A right subtemporal decompression was performed, Nov. 28, 1919: there was a decided increase in intracranial pressure; but on opening the dura, a considerable amount of cerebrospinal fluid escaped and before closure of the wound the tension had subsided appreciably.

Feb. 19, 1920, Dr. deSchweinitz reported that the choked disks had subsided markedly, and, Dec. 2, 1920, the choked disks had practically disappeared.

Meanwhile the patient has completed the studies of the senior class at college and has acquired a bachelor's degree. She is now symptom-free (Fig. 4).

SUBTEMPORAL DECOMPRESSION

We must revise our earlier conception of the value and source of decompressive operations, and particularly the subtemporal decompression. Its greatest sphere of usefulness was thought to be as a palliative measure in tumors recognized as inoperable. As a matter of fact, its greatest sphere of usefulness is really first in cases without tumors, such as the case above reported and, secondly, in cases in

Fig. 4.—Patient, one year after subtemporal decompression. She had fully recovered from the symptoms suggestive of tumor. The underlying pathology was probably meningitis or leptomeningitis.

which the existence or location of the tumor is in doubt, and the operation is employed as one of temporary expedience, in the hope that continued observation may reveal the true nature of the lesion.

While not deprecating subtemporal decompression in tumors recognized as inoperable—one frequently must resort to it though recognizing its limitations—we must acknowledge a disappointment in the duration of the relief it affords, and the reason of this is obvious. We now

know, what at first we did not realize, that the size of the hernia, established at the site of the opening has no relationship to the size of the growth, nor is the increase in the size of the hernia proportionate to the rate of growth of the tumor. The decompression opening affords an opportunity for the ventricles to dilate and the space presumably provided for the relief of pressure, occasioned by the growth, is soon appropriated by the dilated ventricle (Fig. 5).

As internal hydrocephalus is so frequent an accompaniment of brain tumor, no matter where its location, I frequently combine ventricular drainage by callosal puncture with subtemporal decompression. By this combination, a two-fold purpose is served. There is less likelihood of laceration of the cortex when the dura is opened under conditions of extreme intracranial pressure, and the measure of

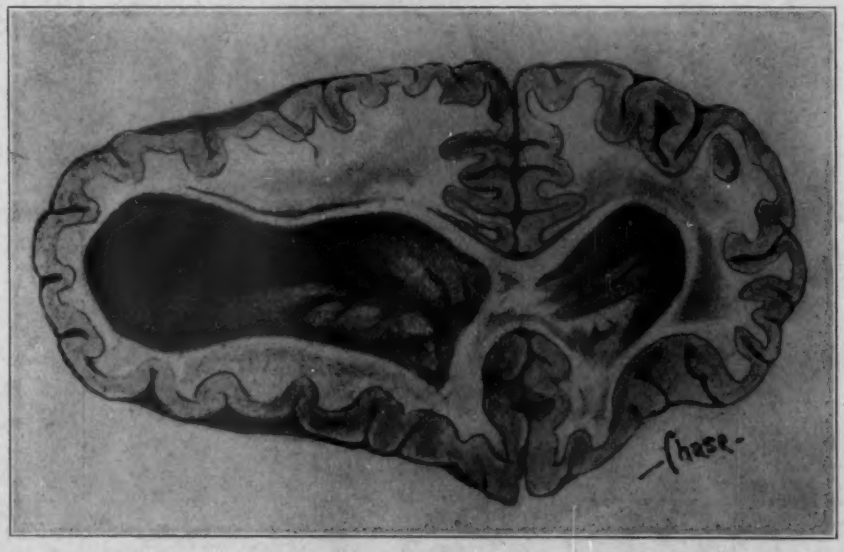

Fig. 5.—Drawing from a specimen with an internal hydrocephalus, illustrating the effects of a subtemporal decompression. Note how much of the hernia at the site of the decompressive opening is represented by the dilatation of the ventricle.

relief of pressure thus afforded is greater and of longer duration. In course of time, variable to be sure, the opening in the corpus callosum unfortunately closes.

MAJOR TRIGEMINAL NEURALGIA

It is just twenty years since the first purposeful section of the sensory root of the gasserian ganglion, after the proposal of Spiller, was performed for the relief of trigeminal neuralgia. It was not until a year's investigation in the experimental laboratory proved the

soundness of the suggestion that I undertook the operation in my clinic. Since that time, of the 554 patients I have seen with trigeminal neuralgia, I have performed the Spiller operation 218 times and have seen the mortality reduced first to 5 per cent., then to 3.5 per cent. and now to less than 1 per cent. In the last 177 cases there has been but one operative death. In every respect, it is the most satisfactory of operations and has reached a stage of refinement that makes one feel that this chapter in neurologic surgery might be considered closed. Recently I have been able, by a modification in technic, to conserve the motor root and in so doing to prevent the atrophy of the temporal, masseter and pterygoid muscles, a matter of considerable importance, both because of the cosmetic result and

Fig. 6.—Characteristic sella deformation of a primary intrasellar lesion. The primary lesion in this case, however, was a suprasellar tumor—an endothelioma of the optic nerve. Compare with Figure 7.

because of the greater ease with which the patient can masticate food. The time is now past when a patient suffering from this most intolerable of neuralgias should not be given immediate relief. Alcoholic injections in practiced hands give immediate, though transitory, relief. These, or the major operation, are the alternatives. There are no substitutes. Needless to say, these dogmatic statements apply only to the major or epileptiform neuralgias of the trigeminal nerve. I hear and read much about sinus disease and focal infections as etiologic factors of the major types. I can recall but two cases in which sinus disease seemed to bear any relationship to the pain, and in both these cases the clinical picture was not that of the major form.

Not to be misunderstood, I repeat that what I have said of treatment applies to what I have called the major trigeminal neuralgia, a term we should adopt by common consent, in all dissertations or discussions, to mean that particular form of neuralgia first described by Fothergill. Its recognition is not difficult. But we must not forget that there remain, exclusive of the major form, a great many pain phenomena in the zone of the trigeminal nerve, some of which

Fig. 7.—Patient (right) with acromegalic symptoms.

do not originate in any lesion of the trigeminal tract. Here is a fruitful field for investigation that brings in, among other things, the part that the sympathetic system may play. I am not referring here to the neuralgias that may arise from any infective focus, from herpes or from tumors.

SURGERY OF THE PITUITARY BODY

As Murphy, with his button, opened up the field of gastro-intestinal surgery, so Hirsch, of Vienna, with his transsphenoidal approach first revealed the possibilities of a surgical approach to the pituitary body. Credit should be given to Schloffer, who, in 1907, performed the first successful operation on the pituitary body. We have come to recognize two methods of approach, the transsphenoidal and the transfrontal, and when I described my transfrontal method of approach, in 1912, I was disposed to advocate this as the method of choice, but since then my views have been revised. There is no doubt that when, as is so often the case, the lesion has extended well beyond the confines of the sella and is as much suprasellar as intrasellar, an adequate exposure and an attempt at radical removal are possible only by the intracranial approach.

The deepening of the sella turcica indicates downward growth, but gives no clue to the upward intracranial extension. Before the posterior clinoid processes are destroyed, the lesion has often broken

Fig. 8.—Drawing of endothelioma removed from the upper thoracic cord of a patient who had had symptoms for four years. The patient was still able to walk and there was only partial loss of sensation.

through the diaphragm and become an intracranial growth. And even a sellar decompression will not retard the growth upward. Then too, we must remember that the sellar deformation and the clinical picture may be very misleading. I have had under my care patients in whom the sellar deformation and the symptomatology were quite characteristic of a primary intrasellar lesion. And yet at operation the primary lesion was found to be a suprasellar growth. The pituitary disturbances were secondary (Figs. 6 and 7). But, admitting its theoretical advantages, the intracranial suprasellar operation is a very much more formidable procedure, and in view of the fact that in most instances life is not threatened by the lesion itself, so often a benign adenoma or a hyperplasia, the more serious of the two operations should be reserved for the final rather than the initial step in the surgical program. It is interesting to note that in the last two years we have had no fatalities following the transsphenoidal method.

Manifold as are the clinical evidences of a disturbed pituitary function, the paramount indications for surgical intervention, after all, are disturbances of vision and headache, both pressure phenomena. The simple sellar decompression, while in no sense a radical operation, meets the immediate requirements, and, if performed before optic

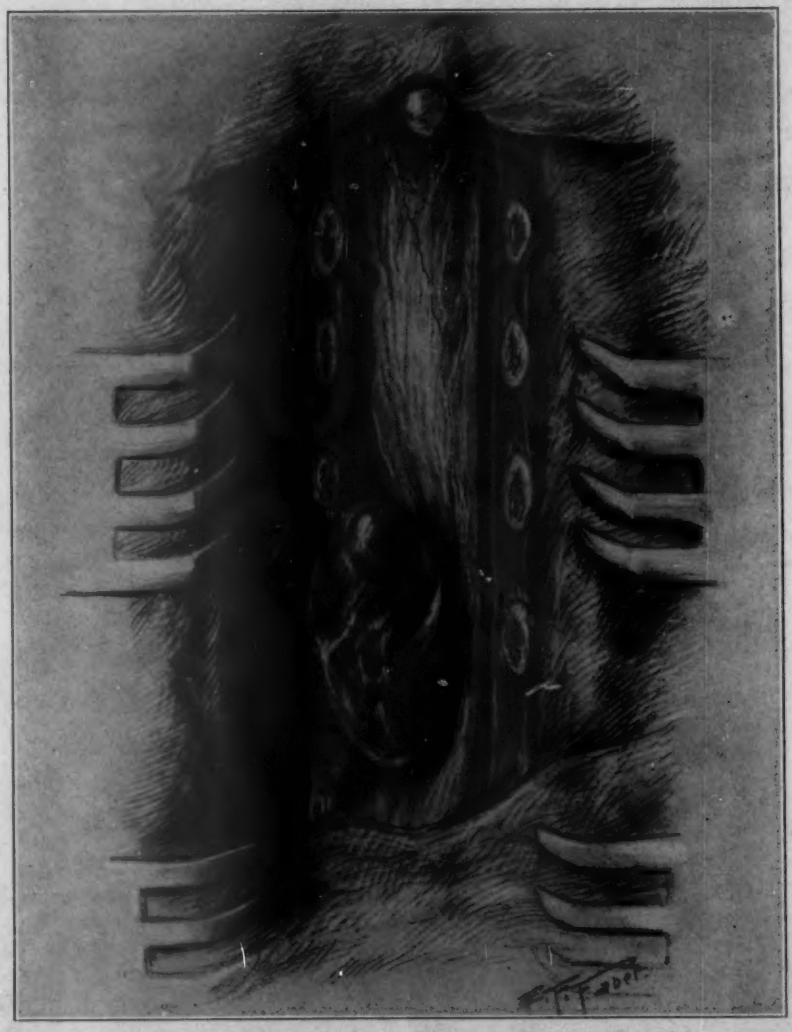

Fig. 9.—Drawing, at operation, of an extramedullary endothelioma. Three weeks after its removal, sensation was restored and the patient was able to walk.

atrophy is too far advanced, will be followed by an almost immediate restoration of the contracted visual fields to normal. And since we have found that radium and roentgen rays have a retarding influence

on the growth of the pituitary lesion, we have in these agencies some assurance against the recurrence that often follows the sellar decompression.

TUMORS OF THE SPINAL CORD

Spinal cord tumors, for obvious reasons, present fewer difficulties as to diagnosis, localization and exploration than brain tumors. In looking over my records, I find there were but three instances in which the tumor was not found, twice because of errors in diagnosis and once because of an error in technic. The restrictions as to space within the bony canal limit the size of the tumor and at the same

Fig. 10.—Patient after resection of the posterior roots of the seventh, eighth, ninth and tenth thoracic segments of the spinal cord. The area of anesthesia is included within the markings.

time facilitate the problem of exploration. Extramedullary tumors fortunately are more common than intramedullary growths and the majority of these are encapsulated. The relation between the various cord segments and their roots to the cutaneous segments, on the one hand, and their muscular terminations, on the other, is so definitely established that accurate localization is the rule. All these are factors which make spinal cord tumors so favorable for surgical intervention. I have been impressed with the number of cases in which the clinical

history and the syndrome do not conform to type, in one particular or another. It may be that pain is absent; it may be that in the history one cannot trace the three characteristic cycles: (1) of root irritation, (2) of the Brown-Séquard syndrome, (3) of vesicorectal involvement; whatever it is there are enough atypical cases to justify an appeal for earlier exploration in doubtful cases. There has been too much procrastination, while waiting for absolute and confirmatory evidence. It is surprising how the clinical picture may vary when the lesions are almost identical. I recall two recent instances in which tumors were found of almost equal dimensions. In one there was a complete paraplegia; in the other, with a clear history of four years' duration, the patient was able to walk, though handicapped more by

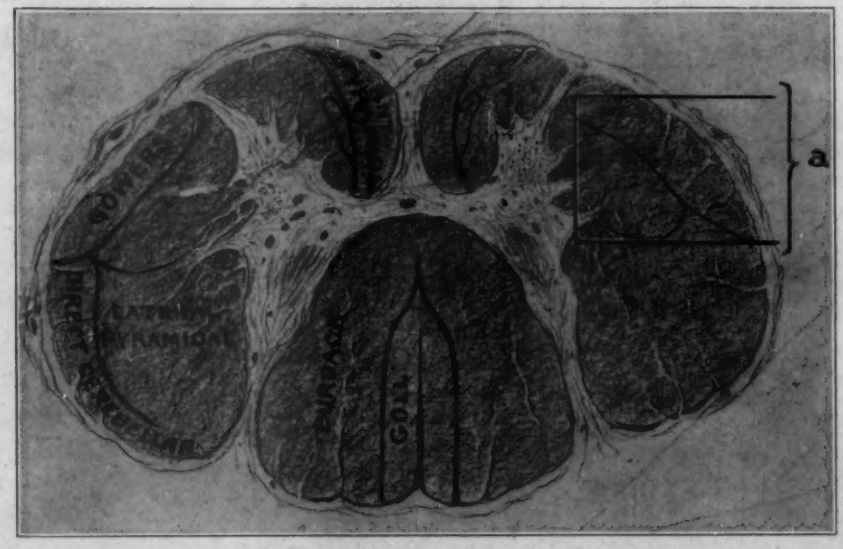

Fig. 11.—The spinal cord at the level of the sixth thoracic segment. Cutting the anterolateral columns of the cord, as described, implies section of that portion of the cord included in the area marked *a*.

spasticity than by weakness. I was in great doubt as to the propriety of operation, and yet we found a relatively large endothelioma (Fig. 8).

We have been too cautious in the spine, as in the cranial cavity, in our attitude toward exploration. Given a case of a complete or partial transverse lesion of the cord that cannot be explained satisfactorily on a basis other than tumor, even though the tumor picture is not clear, an exploratary laminectomy should be undertaken without hesitation. Too often are we called on to operate on patients with complete paraplegia because of needless hesitation and delay. The risks of operation are nil. We have had no fatalities in our entire tumor series. It was only a few weeks ago that I urged

an exploratory operation on a patient with an advanced spastic paraplegia, who under the advice of a most competent neurologist was counseled not to be operated on, presumably because at no time had she experienced pain. A large extramedullary, encapsulated endothelioma was found and readily removed (Fig. 9).

SURGERY OF THE SPINAL ROOTS

The surgery of the spinal roots has had rather a hectic career. In 1908, section of the posterior roots for the relief of spasticity was first proposed (Förster). By so interrupting the afferent impulses, it was thought spasticity could be controlled. Sound as the physiologic basis for this operation, the results of a fairly comprehensive application in my clinic have not justified its acceptance as a reliable procedure. There are many aspects of this problem that might be discussed in the arguments pro and con. Suffice it to say now that so many roots must be cut to obtain the desired result that the question resolves itself into a rather heroic procedure, one disproportionate to the degree of improvement in locomotion and not tolerated well by the class of patients to whom it is applicable. Be it remembered, too, that the residual muscle power cannot always be forecast and the relief of spasticity does not therefore imply a return of easy locomotion. We must pronounce the operation, therefore, for the time as *sub judice*. In fact, looking on the surgery of the spinal roots from every angle, we have yet much to learn. There would seem to be an analogy between section of a spinal root central to its ganglion and section of the trigeminal root central to its ganglion, and yet I have been disappointed in some of my results when posterior root resection was performed for the relief of pain, the pain of intercostal neuralgia (Fig. 10), of postherpetic neuralgia, of brachial plexus neuralgia and of painful stump. The operation is not a new one; it was performed by Abbe in 1888. But the field is one in which there is an opportunity for investigative study as to the failure to secure the absolute relief that follows section of the root of the gasserian ganglion. Is it because there is a larger representation in cutaneous areas than we are wont to believe, or do the sympathetic fibers play a part, or, as has been suggested, are all the afferent fibers not contained within the posterior root? While the problem at first sight seems uncomplicated, I am convinced there are phases of it, anatomic and physiologic, that are not clearly understood.

CHORDOTOMY FOR THE RELIEF OF PAIN

In view of the unsatisfactory state of operations on the posterior roots of the cord for the relief of painful conditions, it is fortunate that a substitute measure has been found that gives greater promise

of more enduring results. In 1912, Spiller proposed for the relief of intractable pain the division of the anterolateral columns of the cord (Fig. 11). His recommendation was based on the assumption that the fibers for pain were confined to one system and that pain sensations could not be conveyed by any other. This assumption has been confirmed in his experimental laboratory and in my clinic.

I have performed the operation six times with satisfactory results in all but one. In this case the patient had suffered incessant pain for two years. After the operation, he enjoyed absolute relief for several months, when the pain returned. As the cord cannot regenerate at the site of suture, it is difficult to account for the recurrence after a period of relief. One must assume, of course, that the columns were not completely divided. The operation, as we have planned it, calls for a section of the cord, 2.5 mm. in its transverse and 2.5 mm. in its anteroposterior diameters, and recently we have overcome the

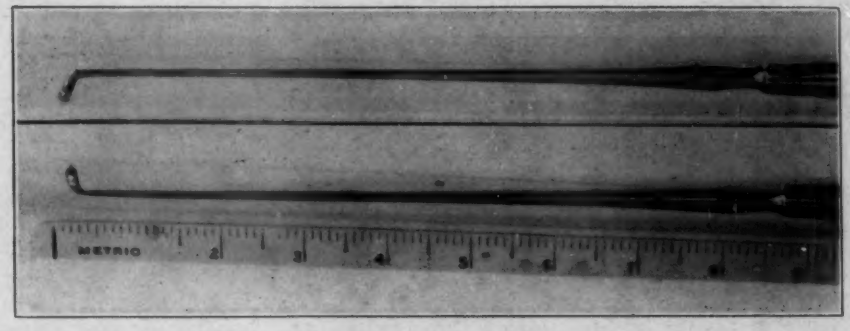

Fig. 12.—Instruments used by the author in section of the anterolateral columns of the cord. The dimensions of the mounted needle correspond exactly to the amount of cord tissue to be sectioned.

difficulty at first experienced in cutting the prescribed amount of tissue, not too much or too little, by the use of an instrument designed for this purpose (Fig. 12).

One might well ask under what conditions such an operation would be indicated: chiefly as a palliative measure to relieve the intolerable pain of malignant growths involving cord or lumbosacral plexus. Three of my cases were of this character. The other three were gunshot wounds of the spine, involving either the posterior roots or the lumbosacral plexus. I can conceive, however, of a wider application to include, possibly, aggravated forms of tabetic crisis, painful neuralgias of the thorax or lower extremities. It must be borne in mind that after this operation there is, or should be, total loss of temperature as well as pain sense. This is inevitable and must be taken into account when the operation is under considera-

tion. The operation, of course, has a limited application; but I have been so impressed with the results that I shall continue to use it as indications arise.

MATTERS OF TECHNIC

In recording and reviewing some of the achievements in the surgery of the nervous system, I have spoken little of matters purely technical. The mechanics of spinal or cranial surgery are easily acquired and it matters little with what tools the individual surgeon prefers to remove the laminae or section the skull. The patient should be surrounded with every safeguard. In the necessarily prolonged ordeals of cranial explorations, the administration of the anesthetic must be entrusted to an anesthetist competent and accustomed to the ways of the operator and to the operation. During the war, rather from necessity than choice, local anesthesia was employed in operations for cranial injuries, and since then some surgeons have attempted to popularize it in cranial explorations for tumors and the like; but I am not at all in sympathy with this innovation, and I believe it will prove to be only a passing fad.

The control of hemorrhage is of the utmost importance, and when feasible I transfuse every patient, as a matter of routine, after a suboccipital craniectomy and after certain other prolonged cranial explorations. It is amazing how much more rapidly the patient recovers from the immediate effects of the operation and how much shorter the convalescence. As a matter of convenience and, if necessary, of economy, we have resorted to autotransfusion. If the blood picture justifies it, we remove from 500 to 600 c.c. of blood from the patient the day before the operation. The blood is citrated and kept on ice until after the operation, when it is heated and returned to the patient.

The great problem, after all, with which the cranial surgeon is almost constantly confronted is how to deal with increased intracranial tension. Unless able to cope with this, the surgeon can never be master of the situation. Successful exploration of suprasellar lesions, of angle tumors and, in some instances even, of cortical or subcortical growths can only be safely accomplished when the tension can be reduced. This is usually possible by ventricular puncture. While as a rule the ventricles are dilated occasionally, they are collapsed, and recourse must be had to lumbar puncture, though not without attending risks.

The ventriculogram may be of service in certain exceptional circumstances in this connection. On one occasion in an exploration of the left hemisphere for tumor, the tension was so great I was afraid to reflect the dural flap until the tension was at least partially relieved,

by the withdrawal of fluid from one ventricle or the other. In each attempt, I failed to find first one, then the other, ventricle and abandoned further exploration. A week later I discovered with the ventriculogram that both ventricles were collapsed. Though cognizant of the risk, I realized that what fluid there was in the subarachnoid space would have to be removed by lumbar puncture. Accordingly, at a second sitting, 50 c.c. of fluid was withdrawn and the tension so relieved that the subsequent exploration and removal of the growth was easy of accomplishment. Originally, Dandy introduced the ventriculogram as a means of localization; but thus far it has not aided me in establishing the location of a growth not indicated by other signs.

As a means of controlling increased intracranial pressure during exploration, the intravenous use of saturated salt solution has been proposed. In the laboratory, Weed and McKibbon observed, as a result of tissue dehydration, a shrinkage in brain volume. Already one or two isolated instances have been reported [1] of rather startling effects. I regret it has not been of service in my hands. The method is not unattended with risk so that it is far from being regarded as a recognized or approved procedure.

CONCLUSION

I have touched but briefly on subjects that are now commanding attention. There have been notable achievements on the one hand and sorry failures on the other. For the coming generation, there are many fields still open for investigation, many problems still unsolved. The shortcomings and disappointments should stimulate, rather than discourage. That there is a wide enough scope for investigative pursuits to justify the recognition of neurosurgery as a specialty no one will question. Certain it is that the promise of the future lies in the hands of those who will give it their undivided attention.

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1. Sachs, Ernest, and Belcher, G. W.: Use of Saturated Salt Solution Intravenously During Intracranial Operations, J. A. M. A. **75**:667 (Sept. 4) 1920.

A REVIEW OF A YEAR'S SERIES OF INTRACRANIAL TUMORS

JUNE, 1920, TO JUNE, 1921

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The object of this report is to give a survey of the 255 cases, with the presumptive diagnosis of "brain tumor," that passed through Dr. Cushing's service during my twelve months' period as his assistant. All patients referred to the hospital as possible tumor cases (suspects) have been included, even though further investigation has proved the condition to be other than tumor.

A year ago one of my predecessors, Dr. Percival Bailey, made a report [1] on the working classification of brain tumors then in use in the clinic. In grouping the present series, a few modifications will be made in the program which he employed. The cases will be presented under four main divisions:

1. *Verified Brain Tumors.*—In this group, the diagnosis, with the few exceptions to be noted, has been determined by the histologic examination of tissue secured at operation or necropsy.

2. *Unverified Brain Tumors.*—In these cases, though the diagnosis of brain tumor is almost certainly correct, the lesion has not as yet been disclosed and hence its histologic character remains undetermined.

3. *Brain Tumor Suspects.*—This group consists of borderline cases in which the diagnosis remains uncertain though the symptoms are strongly suggestive of tumor.

4. *Nontumor Group.*—This includes the cases referred to the hospital as tentative tumor cases, but in which, as the result of necropsy or of careful clinical study, the conditions were proved to be, or have come to be regarded as, other than tumor.

CLASSIFICATION OF CASES

The 255 cases of the year's series are numerically apportioned in these four groups under the subdivisions shown in Table 1.

This classification differs from the one presented by Dr. Bailey in the following ways: Under Group A of "verified tumors," a subdivision (1-b) of those "verified macroscopically" has been introduced.

1. Bailey, P.: Concerning the Clinical Classification of Intracranial Tumors, Arch. Neurol. & Psychiat. **5**:418-438 (April) 1921.

This is to accommodate certain tumors exposed at operation but which proved so vascular as to prohibit removal of tissue for study. Three of these tumors were obviously angiomas.

A fourth group of nontumors has been introduced in order to cover two kinds of cases: (1) certain suspected cases of tumor which were finally proved by necropsy to be conditions other than tumor; (2) cases which were referred to the clinic as possible tumor but which on careful study proved to be so obviously something else that they should not properly be regarded even as tumor "suspects." For instance, a patient with progressive muscular atrophy with bulbar palsy, although sent in with a tentative diagnosis, by a local physician, of cerebellar tumor, was without hesitation placed in the nontumor group.

TABLE 1.—General Classification of Cases

A. Brain Tumors Verified:	
1. At operation (a) microscopically proved	86
(b) macroscopically proved	6
2. At necropsy (unverified at operation)	12
3. At necropsy (unoperated)	3
Total	107
B. Brain Tumors Unverified:	
1. Evidence disclosed at operation (a) subtemporal decompression	15
(b) exploration	31
2. Unoperated	14*
Total	60
C. Brain Tumor Suspects:	
1. Clinically doubtful (unoperated)	49
2. Clinically operable (negative tumor findings)	7
Total	56
D. Nontumor Group:	
1. Clinically tumor suspect (necropsy no tumor)	6
2. Tentative tumor diagnosis not supported	26
Total	32

* Several of these are in the wards awaiting operation.

The group contains, nevertheless, a number of patients sent in as acoustic tumor suspects in the stage before choked disk or cerebellar symptoms have set in, and though they have been discarded, some of them in time may actually prove to have tumors.

Because Dr. Bailey was chiefly concerned with discussing the group of tumor suspects, which are more interesting from the standpoint purely of neurologic diagnosis, he placed this group first in his classification. This has been reversed in favor of the verified tumors, which are, after all, the more important from a therapeutic point of view.

It is not infrequent that a single case while under study, whether the patient is temporarily discharged from the hospital or not, shifts its position in the classification from one group to another. These changes may be illustrated by a case which passed step by step from Group C to Group A.

CASE 1 (Surg. No. 13783).—*A case primarily a tumor suspect* (Group C); *questionable thrombosis syphilitica. Subtemporal decompression; tumor unverified* (Group B). *Two-stage exploration; neuroblastoma verified* (Group A).—*History.*—Jan. 4, 1921, A. S., a farmer, aged 49, married, was admitted, complaining of recent weakness of the right arm and leg. The father and mother had both died of cardiovascular disease. The wife had had no miscarriages. There had been one child, who was living and well. The past history was unimportant, except for frontal headaches attributed to eye strain during the last twenty years.

Present Illness.—Dec. 14, 1920, three weeks before entry, the patient wakened about daybreak with a severe left frontal headache. He slept again, but on arising in the morning felt tired and bewildered. He went to work but came home at noon with a sensation of numbness of the right arm and leg. The following day he noticed that his right leg dragged somewhat.

Frontal headaches continued and were severe, and the weakness of the right arm and leg became progressive. Ten days after onset, there was a second more severe "attack of numbness of the right arm and leg," and following this the leg became so weak that the patient was confined to bed. His speech also at this time became hesitant, with some misuse of words.

Physical Examination.—He was well developed and nourished, of slow mentality, bewildered and mildly euphoric. Speech was somewhat incoherent, words were confused and incorrectly pronounced, and there was some apraxia. There was a hemiparesis of the right lower side of the face, arm and leg, as well as a hypesthesia of the right arm, leg and trunk. Some spasticity and a Babinski reflex were present on the right side.

Eye: The fundus of the right eye was pale, showing secondary atrophy with an elevation of 2 diopters. The margins of the disk were hazy and the retina showed very extensive choroiditis with numerous large patches of pigmentation. The left eye showed no choroiditis and no atrophy. There were a few linear hemorrhages, and the disk also measured 2 diopters.

Urinalysis and blood Wassermann test were negative. The roentgen ray revealed suggestive evidence of increased intracranial pressure.

The loss of power, with numbness in the right arm, leg and face, with aphasia indicating an extensive lesion of the left hemisphere, might well have been produced by thrombosis of the middle cerebral artery. The choroiditis suggested syphilis. In the hope of gaining more evidence, a lumbar puncture was made and a few c.c. of fluid, not under excessive pressure, were slowly withdrawn. It contained four cells per c.c. and no increase in globulin. A + Wassermann reaction was reported in 1 c.c. dilution. Although a positive diagnosis was not made, the symptoms and signs were sufficiently suggestive of syphilitic thrombosis, so that the patient was kept under observation and operative procedure deferred. Had the patient been discharged or transferred at this time the classification would have been "Brain tumor suspect: syphilitic thrombosis? (Group C)." He was recommended for transfer to the medical service.

Course.—During the next ten days his condition became progressively worse, with subnormal temperature, and pulse of about 60. Drowsiness became more marked. The degree of right hemiparesis and hemianesthesia increased. Aphasia became more pronounced, until his vocabulary was limited to "yes" and "no." Headache was severe, and he vomited on two or three occasions. The disks now measured 3 diopters. The condition, whether due to tumor or edema, evidently demanded operative relief.

Operation.—January 17, a left subtemporal decompression was performed. This disclosed a tight brain with flattened convolutions and without surface fluid. The ventricular tap was dry.

At this point, owing to the conditions found at operation, the diagnosis shifted the case from the suspect group to that of a probable tumor, and had he been discharged without further intervention it would have been with the diagnosis "Brain tumor: unverified (Group B)."

Postoperative Course.—Following the decompression he improved markedly. There was some return of strength in the right arm and leg. His vocabulary increased so that he could, to a limited extent, respond to questions. Apraxia was still evident, and when given a candle and box of matches, he looked at them blankly and could not demonstrate their use. The decompression bulged markedly.

Because of this improvement, a left osteoplastic exploration was performed, and a well-circumscribed tumor of the postcentral gyrus was disclosed. Five days later, the flap was reelevated, and the tumor, which had the gross appearance of an endothelioma, was readily enucleated. The histologic report, however, was neurocytoma (glioma group).

He made a remarkably good operative recovery and was soon able to be out of bed. Strength was gradually regained in the leg so that he walked with a little assistance. The aphasia disappeared except for hesitation over an occasional word. The apraxia cleared, and the hemianesthesia was much less in degree. The choked disks subsided, leaving only a moderate formation of new tissue.

Because of the final verification of the nature of the tumor, the case came to be placed among the verified tumors (Group A) and among those histologically identified. Had he succumbed to the first stage of the exploration and necropsy been refused, the verification would have been only macroscopic, and under Dr. Bailey's rulings would, therefore, have remained "Tumor unverified."[2]

Not infrequently do cases shift in this way from one group to another in the records. Undoubtedly, a good many of the unoperated

2. It may be added that this is the chief reason for not classifying a tumor as "verified" without histologic examination, for it was my impression, owing to the circumscribed character of the tumor, its enucleability, and its attachment to the dura, that it was an endothelioma. H. C.

cases in the tumor suspect group may in time have symptoms sufficiently distinctive to justify exploration. But even an operation may sometimes fail to reveal the presence of a tumor, and tumors, indeed, may sometimes be overlooked at necropsy. The following is a striking example. The case, originally a "tumor suspect" (Group C), regarded at operation as "clinically nontumor" (Group D), proved at necropsy, made possible by a postoperative complication, to belong actually in Group A.

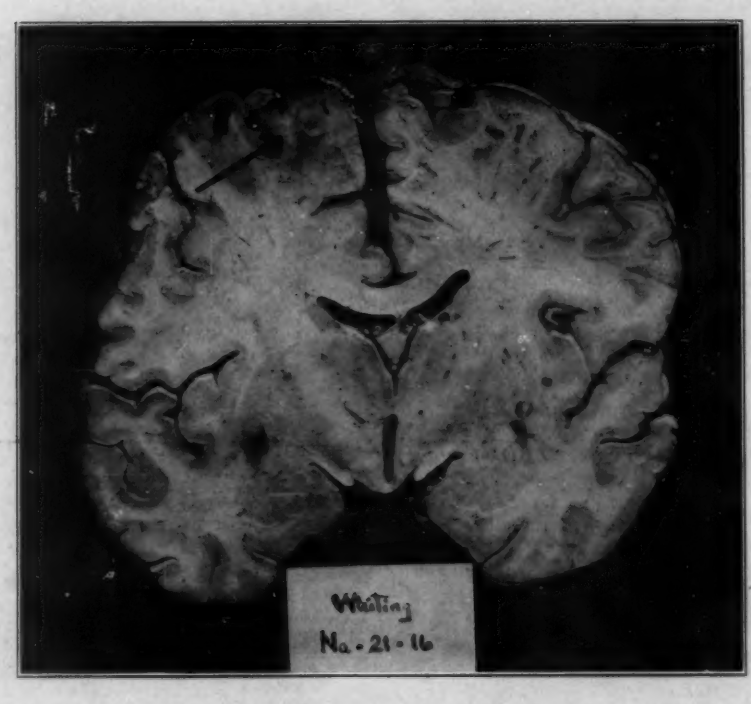

Fig. 1.—Coronal section photographed from in front. Arrow points to minute glioma in paracentral lobule.

CASE 2 (Surg. No. 14497).—*Brain tumor suspect* (Group C). *Exploration of hemisphere negative. Operative diagnosis cerebral arteriosclerosis* (Group D). *Fatality. Small glioma disclosed at necropsy* (Group A).—*History.*—Mr. C. W. W., aged 59, was admitted, May 9, 1921, with a history of recent paresthesia and progressive weakness of the left lower leg. There were no general pressure symptoms whatsoever.

Neurologic Examination.—This was negative except for slight loss of power associated with ankle clonus and some spasticity of the left lower leg. There were no sensory changes and no choked disks. The roentgenogram was negative. A diagnosis was made of presumptive tumor, possibly endothelioma involving the foot center.

Operation.—Right osteoplastic flap revealed a wet brain under no tension and some arteriovascular changes. Thorough exploration in all directions, even to the falx, showed no evidence whatsoever of tumor. The operative diagnosis was cerebral arteriosclerosis. Closure.

Postoperative Course.—Symptoms of the gradual formation of an extradural clot were overlooked. Consciousness was not regained. On the second day the flap was reflected and the clot was removed. The patient died eighteen hours later.

Necropsy.—The primary report on the brain was negative. Subsequent thin sections disclosed a small subcortical glioma, about 1.5 cm. in diameter, in the leg center of the right hemisphere (paracentral lobule).

TABLE 2.—VERIFIED TUMORS, GIVING LOCATION AND PATHOLOGIC TYPE

Location	Glioma	Gliomatous Cyst	Pituitary Adenoma	Endotheli-oma	Pharyngeal Pouch	Neurofib-roma	Carcinoma	Angioma	Tuberculoma	Cholestea-toma	Dermoid	Total
Frontal	2	..	..	1	..	..	..	..	..	..	..	3
Paracentral	6	4	..	5	..	..	2	2	..	..	..	19
Parietal	2	..	..	..	..	..	..	..	..	..	..	2
Supramarginal	3	..	..	1	..	..	..	..	..	..	..	4
Temperosphenoidal	5	2	..	2	..	..	..	1	..	..	1	11
Occipital	2	1	..	..	..	..	1	..	..	..	..	4
Pituitary	..	..	18	..	2	..	..	..	..	..	..	20
Suprasellar	..	..	1	..	5	..	..	..	..	..	..	6
Cerebellar	6	9	..	2	..	..	..	..	2	..	..	19
Extracerebellar	..	..	..	..	..	9	1	..	..	..	..	10
Region fifth nerve	..	..	..	2	..	..	1	..	..	..	..	3
Optic chiasm	1	..	..	1	..	..	..	..	..	..	..	2
Pons and basal nuclei	1	..	..	..	..	..	..	..	1	..	..	2
Lateral ventricle	1	..	..	..	..	..	..	..	..	..	..	1
Parietal and temporal	..	..	..	..	..	..	..	..	..	1	..	1
Total	29	16	19	14	7	9	5	3	3	1	1	107

These two case reports serve to show how the diagnoses, as recorded in the hospital files, may shift on subsequent reentries from one group to another until in time they come to be verified in Group A as tumor, or in Group D as nontumor.

In Table 2 the cases have been arranged roughly in accordance with the primary location and histologic diagnosis. It can be seen that the pituitary cases predominate, the intracerebellar and the para-Rolandic tumors being a close second. It is probable that tumors in other parts of the cerebrum are often overlooked.

THE GLIOMAS

In this short series the true brain tumors constituting the glioma group represent 42.5 per cent. of all the lesions. Tooth[3] in a series

3. Tooth, H.: Some Observations on the Growth and Survival Period of Intracranial Tumors, Brain **35**:61-108, 1912.

of 258 verified cases found 49.2 per cent. of gliomas. Heuer and Dandy [4] in a series of forty-two cases found 50 per cent. Clarke,[5] in ninety-nine cases, found 38.5 per cent. It is safe to say, therefore, that the gliomas represent between 40 and 50 per cent. of all intracranial tumors.

No attempt will be made to subdivide the gliomas and to distinguish neurocytomas, neuroblastomas, gliosarcomas, and so on, from the general group, for the surgical problem is the same for all and prognosis differs in no great respect. This is largely a matter for the neuropathologist, and this series is too small to draw any particular conclusions from these finer subdivisions.

From a surgical standpoint these tumors are by no means to be regarded as therapeutically hopeless, for certain of the gliomas are enucleable, and some of the gliomatous cysts when properly treated apparently are curable lesions. Dr. Cushing has pointed out [6] that the first two successes in his tumor series, with apparent cures lasting over thirteen years, were: (1) a solid glioma, and (2) a large gliomatous cyst, both of the cerebellum. Even a large gliomatous tumor of the infiltrating type originating in the left hemisphere may offer a surgical problem not entirely hopeless. An illustration of this is the case of a physician's wife, who had been readmitted to the clinic on several previous occasions, though she first came under my observation in 1920. Though it is now twelve years since her first symptom of tumor, she still leads a comfortable existence and is able to look after her home duties.

CASE 3 (Surg. No. 14226).—*Glioma of left hemisphere with symptoms of twelve years' duration. First pressure symptoms five years ago. Repeated partial extirpations of tumor with marked relief of symptoms and signs.—History.*—Mrs. A., a physician's wife, in 1909, twelve years ago, began to have convulsions. These were usually of the petit mal type, but twice were generalized, without a focal element and with immediate loss of consciousness. It was not until seven years afterward (1916) that the patient developed pressure symptoms of headache and vomiting. At this time choked disks were found.

In September, 1916, she entered the Peter Bent Brigham Hospital, and a right subtemporal decompression was performed for an "unlocalized brain tumor."

During the next few months there were frequent attacks of numbness of the right arm, associated with weakness and awkwardness of that extremity. Reflexes were exaggerated, and there were some vasomotor disturbances in

4. Heuer, G., and Dandy, W.: A Report of Seventy Cases of Brain Tumor, Bull. Johns Hopkins Hosp. **27**:224-237 (Aug.) 1916.

5. Clarke, F.: A Study of the Anatomical Location and Histopathology of Ninety-Nine Brain Tumors, Rev. neurol. & psychiat. **14**:485-505, 1916.

6. Cushing, H.: The Special Field of Neurological Surgery: After Another Interval, Arch. Neurol. & Psychiat. **4**:603-637 (Dec.) 1920.

the right arm. Disks were elevated 2 diopters. An osteoplastic exploration in December, 1916, revealed a tumor about 6 cm. in diameter slightly adherent to the dura in the inferior postcentral region. The tumor, which was supposed to be an endothelioma, was removed apparently *in toto*. The histologic diagnosis, however, was glioma.

She made a perfect recovery and during the following two years she was quite normal, except for occasional attacks of numbness and jerking of the right arm, and two transient periods of aphasia lasting for less than five minutes. These symptoms, however, were comparatively slight and did not interfere at all with her social life, and she was considered entirely normal by her husband and friends. There were no more convulsions or headaches.

In 1918, the decompression area began to protrude, her right arm became weak, and there was some difficulty in writing. She was referred to Dr. W. E. Dandy in Dr. Cushing's absence abroad. He exposed the tumor again, drained

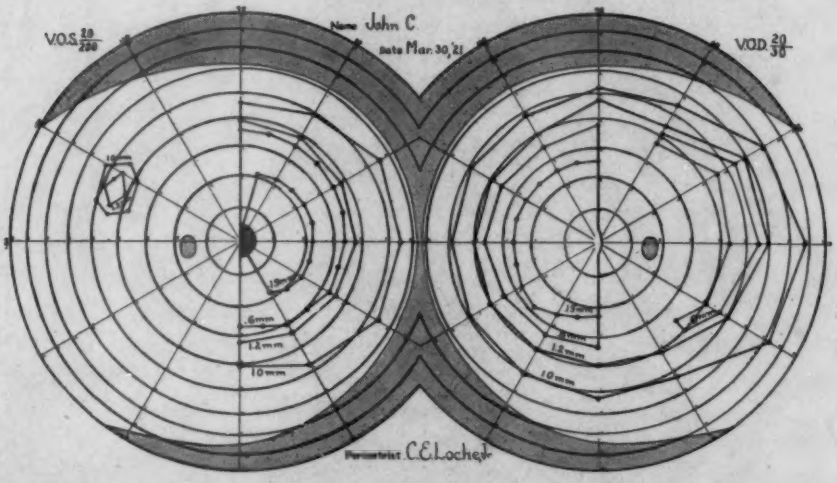

Fig. 2.—Fields of pituitary case, March 30, before operation, showing bitemporal hemianopsia in the left eye except for a small island, and in the right eye complete for smaller test objects.

a large degenerative cyst, and removed a small fragment of what appeared to be a widespread glioma, an impression confirmed by the histologic findings. She subsequently underwent a thorough course of treatment with radium. For the next two years her condition remained very good. Her right arm regained its normal strength, and she resumed her usual activities. During these two years there were very few periods of transient aphasia.

In October, 1920, she reentered the Peter Bent Brigham Hospital, owing to a recurrence of weakness of the right arm and some transient numbness both in the arm and right side of the face. There was increased intracranial pressure as evidenced by a bulging decompression and low grade of choked disk. The right arm showed weakness and slight anesthesia, some astereognosis and loss of muscle sense, as well as exaggerated deep reflexes.

The *fourth operation* conducted at this time consisted in removing a huge mass of tumor which had increased considerably in its area of distribution. It

was amazing that the procedure did not leave her completely aphasic and hemiplegic, but contrary to expectations no additional paralysis resulted and strength in the weak arm was soon partly regained. Periodic attacks in which there was slight aphasia subsequently occurred, but without loss of consciousness. She was remarkably well for another five months.

In April, 1921, because of increasing weakness of the right arm and a somewhat more pronounced aphasia, she presented herself again for study and possible operation, earnestly favored by her husband. At this time, therefore, a *fifth operation* was performed and another large mass of gliomatous tissue was scooped away. She did well, made a prompt recovery, and a recent letter tells of continued improvement since her discharge.

This illustrates, even with the least promising types of glioma, how a useful life may be prolonged for years by repeated comparatively simple operative procedures. The fact that the patient's husband is a physician and fully understands the ultimate outcome speaks well for the success of this unequal combat with a desperate disease by operative measures, several of which have been performed at his insistence under considerable protest.

GLIOMATOUS CYSTS

Though in the long run the infiltrating gliomas like the one mentioned above are the least amenable to surgical treatment of any of the brain tumors encountered, those gliomas which have undergone cystic degeneration are in many respects very favorable for operation and in their results often rival those following endothelioma extirpations. In this series, out of the forty-five gliomas, sixteen were classified as gliomatous cysts, as the cystic element predominated. It can be seen, furthermore, from the table, that the larger number of these were intracerebellar cysts, some of which are very favorable from a surgical standpoint.

According to this series these intracerebellar gliomas are particularly common in children. Indeed, it is interesting to note that out of the nineteen verified intracerebellar tumors fourteen, or 73 per cent., occurred in children. Also, ten of the nineteen verified tumors were cystic, and nine of these were found in children. This is in marked contrast to the series of forty-three cerebral tumors, of which only four occurred in children. Of the forty-three cerebral tumors, six were cysts, and only one occurred in a child. These figures illustrate not only the predominance of cystic gliomas in children but also their favorite anatomic location in the cerebellum.

The diagnosis of a straightforward cerebellar tumor is a comparatively simple matter when the cerebellar symptomatology is full blown. In the absence of the cardinal signs and symptoms, however, it may be most difficult to arrive at a decision. The following case may be cited in illustration.

CASE 4 (Surg. No. 14264).—*Cerebellar tumor suspect despite few cerebellar signs. Exploration; gliomatous cyst verified.—History.*—A school boy, aged 14, was admitted, March 20, 1921, complaining of nausea and vomiting, dizziness, and blurring of vision. In September, 1919, six months previous to entry, he began to complain of afternoon nausea. He was thought by his local physician to have chronic appendicitis. An appendectomy was performed and no pathologic condition demonstrated.

In November, 1920, he began having periodic headaches referred to the suboccipital region. During the next three months, the headache became more frequent, and there was some associated vertigo. No difficulty in gait was noted by the patient or his parents. Early in March, a few weeks previous to his admission, there was some blurring of vision with transient diplopia.

Neurologic Examination.—The only positive findings were: (1) slight suboccipital tenderness; (2) cracked-pot resonance of skull; (3) separation of cranial sutures and convolutional atrophy shown by the roentgen ray, and (4) choked disks of 4 diopters.

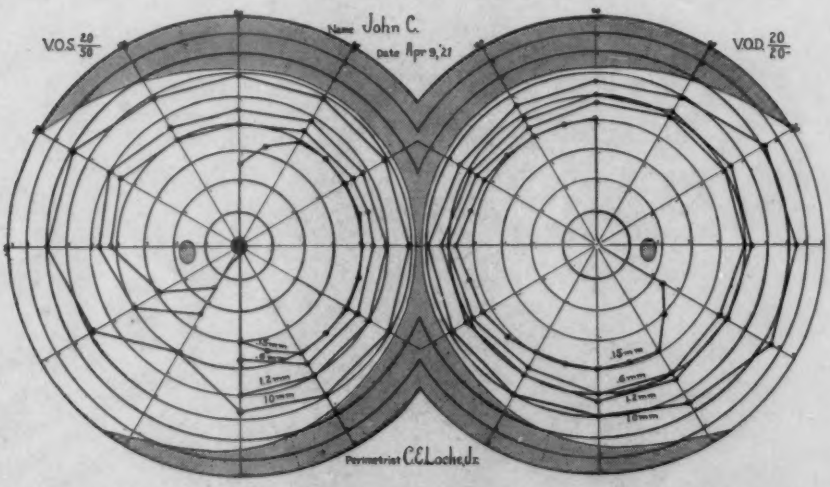

Fig. 3.—Fields on fifth day after transsphenoidal operation.

There was no nystagmus with the head in a vertical position, though when placed obliquely a few twitches occurred. Gait was very good, with no unsteadiness whatsoever. There was no definite hypermetry and no repulsion. There was a possible slight adiadokocinesia on the right, also slight hypotonia of lower extremities with diminished deep reflexes.

Although this case did not present at all a textbook picture of cerebellar tumor, it is quite representative of a fairly large group of cases. A presumptive diagnosis of cerebellar tumor (possible arachnoiditis) was made and a suboccipital exploration revealed a midline large gliomatous cyst. The points in the story that led to this diagnosis were chiefly the suboccipital headaches and tenderness and the diplopia, together with the evident internal hydrocephalus.

Comment may be made on the needless abdominal operation performed shortly before this patient's admission. It has always been the custom of the clinic to have a special paragraph in the histories of all tumor cases in which the previous diagnoses and operations are listed. It is a subject by itself and one which deserves a special report. Though abdominal operations, owing to nausea and vomiting, are not infrequent, those on the nose and throat are by far the more common, as Dr. Cushing has pointed out in some recent papers. This is possibly to be taken merely as indication of the difficulty of tumor diagnosis in the early stages of the process.

PITUITARY ADENOMAS AND PHARYNGEAL POUCH TUMORS

If one is to consider these two types of tumor together in the pituitary group, as is usually done, they represent, next to the gliomas,

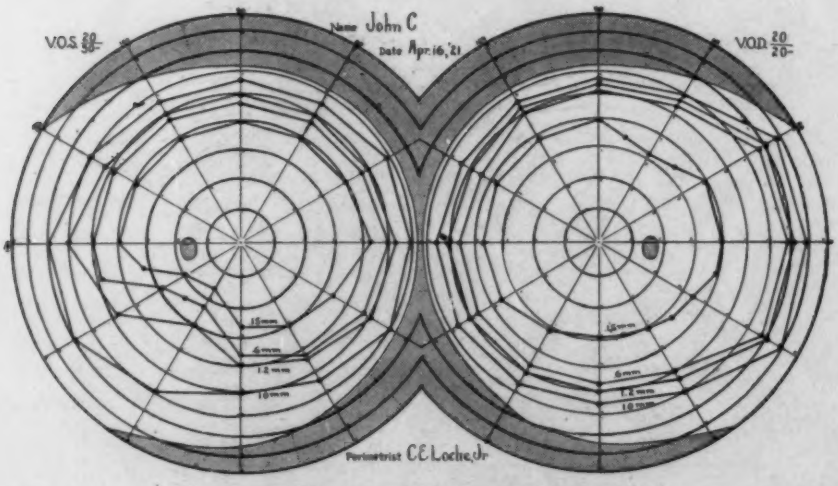

Fig. 4.—Fields on twelfth day after operation.

the largest group from the standpoint of tissue origin. In the year's series, there were twenty-six cases, nineteen of them primary adenomas of the gland and seven of them of pharyngeal pouch origin. By far the larger proportion of these lesions, therefore, were sellar rather than suprasellar, as shown in the table. There were two additional cases which gave typical pituitary signs, i. e., primary optic atrophy, bitemporal hemianopsia, low metabolism, headaches, etc., in which the lesion was also "suprasellar" but unrelated to the hypophysis. One was a glioma of the chiasm and the other a dural endothelioma of the base, both giving direct pressure on the pituitary. These I have placed in the table under optic chiasm.

The therapy of the pituitary disorders in its present stage is directed chiefly toward the preservation of vision. Indeed, loss of vision in my

brief experience is the complaint that brings most of these patients to seek surgical assistance. The usual patient with dyspituitarism disregards in large measure the general manifestations of his disorder—his neighborhood symptoms alone disturb him.

Few operations in surgery can be more gratifying to the patient or more interesting to the attendant, whose duty it is to observe the changes in the fields of vision, than one of these routine transsphenoidal procedures. That they are not unattended by some risk is shown by the results given in Table 3, two fatalities having occurred in the present series. In a few of the cases, moreover, the condition was so advanced that no great improvement in vision occurred after the operation. In the larger number of instances, however, the improvement has been rapid and sometimes astonishing. The following résumé of a case history is a good example.

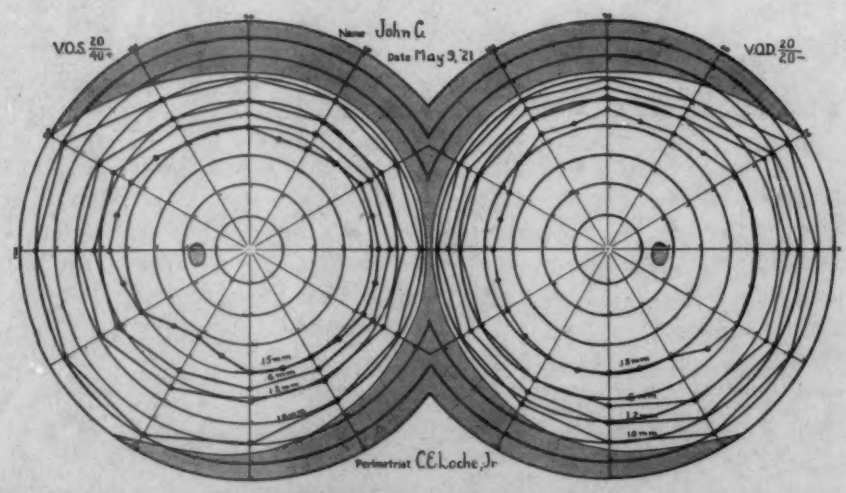

Fig. 5.—Fields one month after operation.

CASE 5 (Surg. No. 14267).—*Pituitary adenoma. Characteristic signs and symptoms. Operation. Relief.—History.*—Mr. C., a lawyer, aged 48, was admitted, March 29, 1921, complaining of loss of vision.

He had always been stout, as are several other members of his family. Between the ages of 25 and 30 he gained in weight from 150 to 190 pounds. About October, 1919, he commenced again to put on flesh, and in twelve months, his weight increased 23 pounds—from 208 to 231 pounds.

In March, 1920, about a year before his admission, he first noticed some blurring of vision, which glasses did not improve. There was gradual failure, particularly in the left eye. He had at times suffered from frontal headaches, though never severely.

Since January, 1921, five months ago, he had not been able to read even large type and he had experienced a loss of libido.

Physical Examination.—The patient was an obese middle-aged man, 5 feet, 6 inches in height, with normal features. The skin of the face was finely wrinkled, soft and of a sallow pallor. The comparative absence of body hirsuties was conspicuous. There was hypoplasia of the genitals. The basal metabolism was — 10. The temperature and pulse were slightly subnormal.

The roentgen ray showed a widely ballooned sella turcica with absorption of its walls. There was a bilateral primary optic atrophy, with marked pallor. The perimeter disclosed a bitemporal hemianopsia (Fig. 2), complete to a 10 mm. disk on the left and to a 0.6 mm. disk on the right, though in each case an island was preserved in the temporal field. Visual acuity on the left was 20/200; on the right 20/30.

Operation and Results.—April 4, a transsphenoidal operation was performed. The floor of the sella was found partially destroyed and the tumor had extended into the sphenoidal cells. The capsule of the gland was split and large masses of soft struma extruded and were removed with the pituitary spoon. He made a prompt recovery with immediate subjective improvement in vision. The extent of this was revealed by his first postoperative charts taken on the fifth day (Fig. 3). He was discharged on the thirteenth day, the fields being nearly normal (Fig. 4), has resumed his professional work, and is able to read small type with ease. The fields have been taken twice subsequently (Fig. 5). The acuity in the most affected eye improved from 20/200 to 20/40 in the course of a month.

In only one of the twenty transsphenoidal procedures was the operation done for another object than preservation of vision. The exception was in the case of an acromegalic with a large sella, who suffered intensely from so-called pituitary headaches. The usual transsphenoidal operation was carried out, with removal of possibly the lower half of the soft adenoma. There was no improvement whatsoever in her complaints. It would seem that acromegalic headaches, a most baffling symptom to relieve, may be due to some other cause than sellar distention. In my experience, the other type of patient, with enlarged sella and hypopituitarism, like the case cited above, has complete relief from headaches as a result of the sellar decompression with partial tumor removal.

It would seem that the chief difficulty confronting the neurosurgeon in these cases is to distinguish between those more suitable for a transfrontal than for a transsphenoidal operation. The fact that on the operative list (Table 3) there are more transsphenoidal and transfrontal operations than there are cases shown in Table 2 indicates that several of these patients had double operations. It is sometimes very difficult to tell in the individual case which is the route to be favored. Two cases, in particular, from this series have emphasized this to me. Both of them showed the rare combination of a bitemporal hemianopsia, a greatly enlarged sella and a choked disk. It was supposed in both cases that there was an intracranial extension of a pituitary adenoma blocking the foramina of Munro. In the first case, a transfrontal operation revealed, on puncture of the ventricle, an internal hydro-

cephalus, but the enlarged gland had not ruptured through its capsule, which was bulging between the legs of the chiasm. Consequently a transsphenoidal operation was subsequently performed but with no real improvement in vision. In the second case, that of a dentist with rapidly advancing blindness, a transsphenoidal operation was the primary one; but it exposed a flattened pituitary body instead of the soft adenoma or adenomatous cyst which was expected. Subsequently, a transfrontal operation was performed, which disclosed a large pharyngeal pouch cyst which was successfully peeled out despite its partly calcareous wall. Recovery was perfect, with rapid restoration of vision practically to the normal, so that he has been able to resume his professional work, which requires good eyesight.

THE ENDOTHELIOMAS

There have been fourteen of these in the series. They should properly be divided into two groups: (1) those arising from the meninges with a definite dural attachment, the more common type, of which there were twelve in the series, and (2) those of supposed pial origin. There were two of the latter, both exceedingly vascular tumors in the posterior fossa, disclosed by a suboccipital operation. Both of them, moreover, were in children, and though the tumors were exposed and have an unmistakable appearance, they were not histologically verified, and have therefore been placed in my Group A, 1-b.

The other and more common endotheliomas are in one sense the most favorable, from a therapeutic point of view, of all tumors, owing to their enucleability when accessible. When, however, they do not primarily involve an area of the cortex, irritation of which gives early evidence of their presence, they may be exceedingly difficult to diagnose and consequently may attain a large size which renders their removal extremely difficult and hazardous. Because of their comparatively slow rate of growth and the lack of reaction in the surrounding tissue, they often fail to produce either a choked disk or other evidences of increased intracranial pressure until late in their development, and the growth may reach almost the size of a baseball before symptoms come to light.

Their presence at times may be revealed by the roentgen ray, owing to the tendency of the overlying bone to become hypertrophied and thickened. This hyperostosis which is due to invasion of the bone by tumor may involve the inner surface of the adjacent cranium or may lead to a great thickening of the bone throughout. Under these circumstances, the diagnosis is readily made, but otherwise it may be difficult in the extreme. The tumors have definite seats of predilection which must be borne in mind when making a diagnosis. As shown by the table, five were paracentral, two were temporosphenoidal, arising from the

meninges of the middle fossa, two arose primarily from the gasserian meninges, if one may judge from the primary symptoms, another was frontal, still another a supramarginal case[7] with global aphasia, and the last was an inoperable tumor overlying the pituitary fossa. These tumors provoke a characteristic reaction in the adjacent blood vessels, and although they themselves are not particularly vascular, the adjoining meningeal vessels and those of the diploe and scalp vessels become greatly enlarged. Indeed, mere palpation of the head sometimes reveals localized pulsation in the vessels of the scalp over the tumor. The meningeal vessels deeply groove the inner table, giving a characteristic appearance easily recognized by the roentgen ray. In consequence of this, operations on these tumors are attended by particular hazards not only from immediate loss of blood but from the likelihood of continued postoperative oozing from the denuded bone flap after its closure. One of these patients died, presumably from hemorrhage. The patient was a feeble young girl with marked pressure symptoms. The tumor was unexpectedly laid bare during an exploration for an "unlocalizable" growth. There was marked bleeding from the bone, and she did not survive for a second-stage procedure (Compare with Case 9 in the list of fatalities).

THE ACOUSTIC TUMORS

These tumors are in number next to the endotheliomas in the series, there having been nine under observation during the year. The particular description of this type of tumor has been covered in Dr. Cushing's monograph on the subject. In the stage in which they usually appear in the clinic, the diagnosis is possibly capable of greater exactitude than in any other form of tumor. Not only the precise location but the histologic character of the lesion can be foretold.

The chief difficulties lie in the attempt to make a diagnosis sufficiently early to permit of a total enucleation. For by the time general pressure symptoms are pronounced and the syndrome of the cerebellopontile angle is full blown, the growth has so deformed the brain stem that attempts to remove it in its entirety have heretofore been disastrous. It has been the chief aim in this clinic to reduce the mortality of these procedures, which up to recent times have ranged from 60 per cent. upward. With this object, a less extensive procedure than an attempted total removal is carried out, namely, what is called an intracapsular enucleation.

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7. Bremer, F.: Global Aphasia and Bilateral Apraxia Due to an Endothelioma Compressing the Gyrus Supramarginalis, Arch. Neurol. & Psychiat. **5**:663-669 (June) 1921.

There are certain cases in which this is not difficult, namely, those in which the tumor cells have undergone fatty degeneration, for under these circumstances the contents of the capsule may be scooped out, leaving little behind but the collapsed shell. When the tumor, however, is dense, fibrous and vascular, this procedure is impracticable, and little can be gained beyond the effect of the decompression.

It has been stated that several of the cases in the group of brain tumor suspects have been of patients sent in under the suspicion of having primary acoustic tumors, and though the auditory signs are sufficiently characteristic of possible primary involvement of the nerve from tumor, we are still somewhat hesitant in operating in such cases until the existence of a small tumor can be assured with more definiteness. It is to be hoped that the time will come when the distressing consequences of a fully developed acoustic tumor can be forestalled. Until then it would be foolhardy to take undue risks or to carry out an unnecessary exploration for a presumed growth which is giving no symptoms beyond partial deafness and may continue in this stage for many years.

Even in the advanced stage of the malady, in which at present the operations are usually conducted, Dr. Cushing confesses to giving way occasionally to the temptation of undertaking a more radical procedure than he has advocated in print. In one of the cases in my series (Case 8 in the series of fatalities), a very favorable one, after thorough enucleation of the tumor contents, the attempt to remove the largely detached capsule and thus complete the enucleation was irresistible. This caused some bleeding in the angle with resultant contusion of the brain stem while controlling it and an early fatality.

TUMORS OF VARIED HISTOLOGY

The remaining thirteen cases in this series represent far less common types of tumor, some of them so rare that they might not be represented in a group of tumor cases of a far greater number.

Carcinoma.—There were five cases so listed. Three of them were recognized as metastatic and the patients were not operated on, verification being possible at necropsy. In one, the lesion was located in the cerebellopontile angle with a symptomatology resembling that of an acoustic neuroma except for its very rapid course. Another was a rare example of adenocarcinoma of the pituitary invading the meninges of the middle fossa and giving trigeminal symptoms which led to a clinical diagnosis of endothelioma of the trigeminal sheath. Not until examination of the tissues removed at operation was the true nature of the lesion disclosed. This patient has made temporarily a good recovery.

Angioma.—There have been three of these rare lesions in the series, and there are not more than six in Dr. Cushing's entire list of nearly 700 verified tumors. In only one of the cases were there any pressure symptoms, that of a small child with a huge diffuse pulsating tangle of vessels of the temporal region. In the other two cases, the only symptoms were of focal epilepsy of recent origin. Both were young adults. In both of them an osteoplastic resection revealed a fairly circumscribed tangle of huge thin-walled vessels the size of a lead pencil, occupying an area about 5 cm. in diameter. In the first case, nothing was done except to ligate a single trunk and to leave subsequently an overlying cranial defect through which the area was radiated. In the second case, a more radical procedure was attempted which nearly led to a fatality from loss of blood. No tissue could be secured in either case, and I have therefore listed these lesions as verified only macroscopically in Group A.

Tuberculoma.—Of the three cases in the series, the lesion in two was in the cerebellum. Both patients survive, but the experience of the clinic gives a very bad prognosis after removal even of an unruptured tubercle. Six months, I believe, has been the longest survival period, though cases have been reported from other clinics of longer survival and perhaps even of cure. In the single postoperative fatality (Case 19), a tuberculoma of the brain stem was disclosed at necropsy. The diagnosis otherwise would not have been verified, for the presence of a supposed right astereognosis led to an exploration of the left hemisphere.

Cholesteatoma.—This was possibly the most remarkable case in the series. It will be reported elsewhere. The tumor, which had produced no symptoms except thinning of the skull, was a huge growth almost displacing the entire hemisphere. It was removed intact by an osteoplastic cranial resection. It had no connection with the ear.

Dermoid.—Still more rare, though a tumor in the same category as the above, was a dermoid tumor the size of a golf ball removed from the tip of the temporal lobe. The patient, a young army officer, had had tuberculous glands of the neck and naturally was under the suspicion of having an intracranial tubercle. Both of these patients made perfect recoveries.

THE OPERATIVE PROCEDURES

In Table 3 I have attempted, in as simple terms as possible, to indicate the number of operative procedures and to couple them with the fatalities, early and late. It is a difficult matter to present, and I am not entirely satisfied with the table, which does not correspond with my general impression of the results. Of the ninety-five operations which resulted in tumor exposure, with partial or total enucleation, there were only eight fatalities, whereas there were twelve fatalities

resulting from the eighty-five operations in which the tumor was not exposed. My impression had been, until these figures were assembled, that the risks were greatly increased by the attempt at enucleation.

The fifty-four lateral osteoplastic flap operations of varying types represent the larger number. Sometimes these operations are conducted with an immediate subtemporal decompression when tension is marked, and even though no tumor is disclosed the flap is replaced. If the operator, however, has been led to open the dura widely, and no tumor, or a tumor obviously not enucleable, has been exposed, it may be necessary, owing to the protrusion, to peel off the reflected bone and close the scalp alone. Though every effort is made, particularly in cases which have a favorable ultimate prognosis, to preserve an intact cranium, it was necessary for the reasons given to sacrifice the bone in eight of the fifty-four operations. These, however, have usually been unfavorable cases.

TABLE 3.—Brain Tumor Operations and Fatalities

Operation	Complete or Partial Tumor Extirpation			Exploration or Decompression Alone			Total Operations	Total Fatalities
	Number	Early Fatality	Subsequent Fatality	Number	Early Fatality	Subsequent Fatality		
Lateral osteoplastic exposure	32	0	1	22	2	3	54	6
Suboccipital exposure	20	0	1	28	3	0	48	4
Transsphenoidal pituitary	23	0	2	0	0	0	23	2
Osteoplastic frontal pituitary	8	0	2	2	0	0	10	2
Local craniectomy	12	2	0	1	0	0	13	2
Subtemporal decompression	0	0	0	32	2	2	32	4
Total	95	2	6	85	7	5	180	20

The ten transfrontal explorations for suprasellar lesions, though also osteoplastic, have been separately listed, as they represent a special type of procedure.

Of the forty-eight cerebellar operations, seven were performed for cerebellopontile angle tumors, and forty-one for tumors of the cerebellum. In twenty-three of these operations tumors were exposed, in ten a chronic arachnoiditis was disclosed as the possible source of the supposed tumor symptoms, and in fifteen no lesion but great tension was found. Of the twenty-three cerebellar tumors brought into view, nine were gliomatous cysts. This, as I have stated, is considered a very favorable sort of lesion for surgical treatment and has an excellent prognosis.

Comment has already been made on the transsphenoidal operations and the basis on which they are conducted. The first twenty-one cases in the series were carried out without accident. The last two led to fatality. In one of them (Case 24 of the following list) the operation

was misjudged. The case was suited for a transfrontal operation, it being a pharyngeal pouch tumor which lay in a distended sella and thereby led to a presumptive diagnosis of pituitary adenoma. In the other case (Case 18 of the fatalities), though one favorable for a transsphenoidal procedure, the patient succumbed from meningitis on the sixteenth day. This gives an operative mortality for the twenty-three transsphenoidal procedures of 8.7 per cent. Of the transfrontal operations there were two fatalities in the ten operations, or 20 per cent. mortality; but as those procedures are carried out for totally different lesions, this comparison of mortality figures means nothing favorable or unfavorable to the route in question, even were the series larger.

The subtemporal decompression of course is employed usually as a temporizing measure in cases with pressure signs either to gain time or when the lesion is not susceptible of localization. In this way, vision may be preserved while the surgeon is awaiting localizing signs. In two of the thirty-two decompressions performed for this purpose, the tumor was unexpectedly exposed in the temporal lobe. There were four fatalities, three of the operations having been permitted by Dr. Cushing in practically moribund patients. I had performed a decompression in one case of like nature which seemed hopeless, yet the patient survived and subsequently had a successful tumor removal.

There were thirteen operations which have been grouped under craniectomy. These consisted of exploration through an opening similar to an enlarged ganglion exposure or through a defect made in an old osteoplastic flap.

There follows a list of the fatal cases.

NOTES ON FATAL CASES

Case 6 (Surg. No. 15429).—A man, aged 24, presented symptoms of a posterior lesion. A ventricle tap was performed which yielded bloody fluid. Cerebellar exploration was negative. The patient died four hours after operation. Necropsy revealed a glioma filling the lateral ventricles.

Case 7 (Surg. No. 13613).—A man, aged 27, presented symptoms of a posterior lesion and complete blindness. There was accidental trauma of the brain during perforation of the skull (paper thin). Cerebellar exploration was negative. The patient died ten hours after operation. Necropsy revealed an enormous subcortical glioma occupying about two thirds of the cerebral hemisphere.

Case 8 (Surg. No. 14229).—A man, aged 49, had typical symptoms and signs of acoustic tumor. Cerebellar exploration and thorough enucleation of a large right acoustic tumor were performed. This resulted in shock and death nine hours after operation. Necropsy revealed a blood clot at the cerebellopontile angle.

CASE 9 (Surg. No. 14387).—A girl, aged 12, presented symptoms and signs of a subcortical tumor of the right hemisphere. Osteoplastic flap exploration revealed apparently endothelioma, with overlying bony changes. The procedure was associated with considerable hemorrhage. Enucleation was not attempted. Shock resulted and transfusion was performed. Death ensued one hour after operation. Necropsy revealed a very large endothelioma of the right hemisphere.

CASE 10 (Surg. No. 13028).—A man, aged 38, entered the ward in a moribund condition. There were few localizing signs, and a questionable left-sided hypesthesia. A right subtemporal decompression was performed. Reaction was poor. Bronchopneumonia developed and the patient died thirty hours after operation. Necropsy revealed a right temporal lobe glioma.

CASE 11 (Surg. No. 13340).—A boy, aged 14, presented neighborhood and glandular pituitary symptoms and very little change in sella. A transfrontal operation disclosed tumor of the chiasm. Postoperative hyperthermia developed and the patient died thirty-six hours later. Necropsy revealed glioma of the optic chiasm.

CASE 12 (Surg. No. 12540).—A woman, aged 60, had a lesion localized in the region of the left fifth nerve. Exploration revealed a widespreading tumor about the gasserian ganglion. Partial extirpation was performed; an attempt at more complete enucleation resulted in a tear of the cavernous sinus. Transfusion was performed. Death ensued four hours after operation. Necropsy revealed widespreading dural endothelioma of basal meninges from chiasm to medulla.

CASE 13 (Surg. No. 14222).—A boy, aged 14, presented a typical picture of intracerebellar tumor. Exploration (Horrax) disclosed a cystic glioma of the right hemisphere. Drainage of the cyst and removal of a fragment of wall were performed. Twenty-one days later the patient died. Necropsy revealed a very extensive glioma of the right and left hemispheres and vermis, partially cystic.

CASE 14 (Surg. No. 12610).—A woman, aged 52, for nineteen years had had jacksonian attacks of the right leg and a clear-cut clinical picture of a parasagittal endothelioma. Osteoplastic flap exploration disclosed a large parasagittal endothelioma. The bulk of the tumor was removed. Consciousness was not regained, and the patient died seven days after operation.

CASE 15 (Surg. No. 13886).—A man, aged 54, had suffered gradual mental impairment, associated with headaches, loss of vision, incontinence, drowsiness and untidiness. Examination revealed choked disks. A right osteoplastic frontal exploration, two stages, disclosed no tumor. Bronchopneumonia developed. The patient died twenty-nine days after operation. Necropsy revealed a huge endothelioma arising from the ethmoid region and separating the frontal lobes.

CASE 16 (Surg. No. 12581).—A woman, aged 31, presented a hypopituitary symptomatology—an extreme degree of exophthalmos, bilateral primary optic atrophy, and a history indicating increased intracranial pressure. A subtemporal decompression was performed; a very tight brain was encountered but no lesion, and the wound was closed. She rapidly went down hill. Bronchopneumonia developed and she died nineteen days after the operation. Necropsy was not performed.

CASE 17 (Surg. No. 14327).—A woman, aged 45, gave a long history of pituitary disorder—primary atrophy, destroyed sella, bitemporal hemianopsia, mental impairment and untidiness. A transfrontal osteoplastic flap operation

disclosed a large suprasellar cyst. There was drainage of chocolate colored contents. The cyst was largely excised and the wound closed. Postoperative hyperthermia and drowsiness developed and the patient died nine days later during a wave of hyperthermia, with a temperature of 107 F. Necropsy revealed remnants of a very large suprasellar tumor.

Case 18 (Surg. No. 14323).—A man, aged 40, gave a typical pituitary history, with gain of weight, loss of vision and impotence. Examination revealed temporal hemianopsia, right eye; blindness, left eye; bilateral primary optic atrophy, etc. A transsphenoidal operation was performed. There was marked visual improvement, the blind eye returning to 20/50 acuity. The twelfth day after operation he had a chill, headache and rigidity of the neck. He died sixteen days after operation. Necropsy revealed basilar purulent meningitis; remnants of intrasellar tumor

Case 19 (Surg. No. 13426).—A boy, aged 8, presented a Weber's syndrome, pressure signs and questionable asteriognosis. Osteoplastic flap exploration was negative. A large internal hydrocephalus was found. Decompression was performed and the wound closed. The patient died twenty-two hours after operation. Necropsy revealed tuberculoma of the thalamus and pons, left.

Case 20 (Surg. No. 13389).—A man, aged 54, entered the ward in comatose condition. There was a history of left hemiplegia and choked disks. A right subtemporal decompression was performed, resulting in an unexpected disclosure of a deep gliomatous cyst. The wound was closed. Postoperative hyperthermia developed. There was no return of consciousness. Bronchopneumonia developed, and the patient died three days after operation. No necropsy was performed.

Case 21 (Surg. No. 14311).—A woman, aged 54, entered the ward in a comatose condition. There was a history of loss of orientation and hallucinations and choked disks. Subtemporal decompression, without anesthesia, showed a tense brain. The wound was closed and the patient died twelve hours later. Necropsy revealed a large right subcortical frontal glioma.

Case 22 (Surg. No. 14497).—This case of small glioma is reported as Case 2 in the body of the article.

Case 23 (Surg. No. 14037).—A woman, aged 50, gave a history of numbness of the right arm, headache, vomiting and amnesia. A right subtemporal decompression was performed. Eleven days after operation, marked stupor developed and soon Cheyne-Stokes' respirations. The patient died fourteen days after operation. Necropsy revealed ependymal glioma, metastatic, of the left superior parietal region and marked edema of the brain about it.

Case 24 (Surg. No. 14011).—A boy, aged 11, presented the usual symptoms and signs of pituitary tumor. Transsphenoidal exploration disclosed a cyst which was drained. Following the operation there was a persistent leak of cerebrospinal fluid. The fourth day after operation he developed headache, high temperature and rigidity of the neck. He died the eighth day following operation. Necropsy revealed purulent basilar meningitis and a pharyngeal pouch tumor.

Case 25 (Surg. No. 13951).—A boy, aged 17, had right hemiplegia and right homonymous hemianopsia and choked disks. A preliminary decompression was performed. An osteoplastic flap revealed negative findings. There was rapid loss of strength. He died fourteen days after operation, bronchopneumonia having developed. Necropsy revealed a large subcortical left temporoparietal glioma.

CONCLUSION

In closing this report I am aware that a year's experience with such a complicated subject as the surgery of brain tumors represents but a beginning. Moreover, the end-results of this series of operations are more important than the immediate results seen only during the course of twelve months. I wish to express my great obligation to Dr. Cushing for allowing me to present this brief review of the cases, in his service, which have come under my care.

POSTOPERATIVE BILIARY FISTULAS

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Biliary fistulas are of great surgical interest because of their manifold causes, the variety of their communications, and the important problems connected with their surgical management. Two types occur, spontaneous and postoperative.

Spontaneous biliary fistulas are surgical curiosities because of the bizarre course which they may pursue. In finding an exit externally they may open at various points in the chest or abdominal wall, or even in the right thigh, but they usually open at or near the umbilicus, probably being directed to this point by the falciform ligament. Spontaneous fistulas may communicate internally with almost any part of the gastro-intestinal tract, a bronchus, the right kidney or the urinary bladder; they may even perforate the pericardium. The rarity of spontaneous biliary fistulas and their curious communications constitute their distinguishing features; they are not included in the series on which this paper is based.

A postoperative biliary fistula which continues beyond the expected time limit, after an apparently successful operation on the gallbladder or ducts, is not only an annoyance to the patient, but is most disconcerting to the surgeon. Failure of the fistula to close spontaneously means that some obstruction prevents the bile from flowing in its normal course; that faulty surgery is probably responsible for the disturbing sequel, and that repair of the fistula may offer serious difficulties. Nor is the situation any less confusing for the surgeon called on to repair a fistula following an operation by another surgeon, for, although spared any responsibility for the fistula, perplexing factors have been added because of insufficient knowledge concerning the findings and details of the original and subsequent operations.

CAUSES OF POSTOPERATIVE BILIARY FISTULAS

A recent review of the 166 cases of biliary fistulas seen in the Mayo Clinic between Jan. 1, 1910, and Dec. 31, 1919, suggested the publication of the series as a basis for some observations on their causes and surgical management. That gallstones and their complications are primarily the cause of postoperative fistulas in a large percentage of cases, is

a fact most apparent in this review (Table 1). The findings at operation, together with the historical data, show that in 85 per cent. of the cases gallstones were directly or indirectly the causative factor. If one includes also the cases in which the original operations were carried out on the assumption that gallstones were present, although stones were not found at operation, the symptoms being due to cholecystitis, there remain only a very few cases in which the symptoms of gallstones did not play a primary part (Table 2).

TABLE 1.—BILIARY FISTULAS

Proved Cause of Fistula		Cases	Gallstones Found at First Operation	Gallbladder Not Previously Removed	Gallbladder Previously Removed	Average Duration of Fistula	Maximum Duration of Fistula	Minimum Duration of Fistula
Stone in the common duct		41	26	41	0	12.4 mos.	4 yrs.	1 mo.
Stone in the cystic duct		35	25	35	0	24.5 mos	9 yrs.	0.75 mo.
Stone in the gallbladder	105	28	14	28	0	37 mos.	11 yrs	3 mos.
Stone in the hepatic duct		1	1	1	0	.....	11 mos.	
Recurrent cholecystitis in residual gallbladder		22	12	22	0	10 mos.	3.5 yrs.	2.2 mos.
Division of the common duct		13	8	3	10	10.8 mos.	5 yrs.	1 mo.
Stricture of the common or hepatic duct	8	11	9	8	3	18 mos.	7 yrs.	2.5 mos.
Stricture of the cystic duct	3							
Cancer of the gallbladder		2	1	2	0	9 mos.	1 yr.	6 mos.
Cancer of the pancreas		4	2	3	1	4.5 mos.	7 mos.	2.5 mos.
Chronic pancreatitis		4	1	4	0	5 mos.	9 mos.	2.75 mos.
"Cirrhosis of the liver"	1	3	0	3	0	.....	9 yrs.	1 mo.
Hepatitis and infected hematoma	1							
"Prolonged tube drainage"	1							
Indeterminate		2	1	0	2	3.5 mos.	5 mos.	2 mos.

TABLE 2.—CASES IN WHICH STONES WERE NOT FOUND, BUT MAY HAVE BEEN PRESENT AT ORIGINAL OR SUBSEQUENT OPERATIONS

Cases	26 (15.7 per cent.)
Stricture of the common or hepatic duct	2
Division of the common duct	5
Recurring cholecystitis	10
Chronic pancreatitis	3
Carcinoma of the pancreas	2
Carcinoma of the gallbladder	1
Cirrhosis of the liver	1
Hepatitis	1
Indeterminate	1

Another obvious fact is that the gallbladder had been removed in only 10 per cent. of the patients with chronic fistulas. The relative merits of cholecystectomy and cholecystostomy are now generally recognized, and the facts brought out in this series of cases emphasize

these relative merits. It is reasonable to assume that by removal of the gallbladder at the first operation a large proportion of these fistulas could have been prevented. Cholecystectomy would have precluded a persisting fistula in the twenty-two cases of chronic cholecystitis; it would have eliminated the group of twenty-eight cases of "stones in the gallbladder," and it would have made the oversight of a stone in the cystic duct very unlikely. Moreover, a stone in the common duct is much more likely to be discovered by the surgeon who performs a cholecystectomy than by the surgeon who contents himself with a cholecystostomy. In cholecystostomy, more risk of an incomplete operation or of overlooking a pathologic condition is involved than in cholecystectomy. To the latter operation is added the further danger of trauma to the hepatic or common ducts, although in a well conducted operation this danger is negligible.

Another point to be noted is that, considering the technical and anatomic difficulties often associated with secondary operations on the biliary tract, the group of cases in which the condition actually producing the fistula is listed as "undetermined" is remarkably small. The surgeon may wisely leave the condition undetermined if he finds that biliary function can be satisfactorily and permanently reestablished without a prolonged investigation which might involve additional risk and serve no good purpose.

PREVENTION OF A BILIARY FISTULA

More important than the variety of conditions which produce fistulas is the question whether or not such a result could have been prevented at the original operation. Because of the margin of error always present in surgery of the gallbladder and ducts, the numerous and varied factors which contribute to an inadequate original operation, and the unknown incidence of stone reformation, it is doubtful whether total elimination of postoperative fistulas can be attained. Taking all circumstances into consideration, however, and excluding malignancy and those cases in which a fistula is deliberately provided for, it would seem that the unanticipated occurrence of a postoperative fistula should be an exceedingly rare sequel to any operation on the biliary tract. The incidence of such fistulas in the Mayo Clinic from 1910 to 1919, inclusive, was 0.1 per cent., twelve in 9,009 operations on the gallbladder and ducts. Four of these twelve persistent fistulas, as shown by subsequent operation, were due to stone in the common duct, four to stone in the cystic duct, three to recurrent cholecystitis in a residual gallbladder, and one to stricture of the common duct following cholecystectomy. The most interesting fact concerning this group of twelve

cases is that, with one exception, the last case mentioned, in no instance had the gallbladder been removed. A series of 5,997 cholecystectomies in the last fourteen years in the Mayo Clinic with but one subsequent fistula, compared with a series of 1,879 cholecystostomies with eleven postoperative fistulas, is a striking illustration of one advantage of cholecystectomy. Cholecystectomy not only invites more thorough exploration, but eradicates more efficiently potential and actual pathologic processes.

FACTORS IN THE PRODUCTION OF POSTOPERATIVE FISTULAS

Causes which lead to overlooking or producing conditions found to be diverting the bile through the fistula may profitably be considered. Surgical inexperience, inadequate exposure, an operation of intrinsic difficulty, a hurried operation, incomplete or careless exploration, failure to remove the gallbladder, accidental injuries to the ducts, and unintelligent use of drainage, are the most apparent indirect causes, and are deserving of some individual comment.

Inexperience.—In surgery of the gallbladder and ducts, inexperience takes a greater toll than in many other surgical fields. First, faulty diagnosis may lead to ill-advised operation for cancer of the pancreas. Second, inexperience is responsible for failure to realize the significance of findings at operation, such, for example, as that clear colorless fluid in the gallbladder (so-called white bile) means obstruction of the cystic duct or complete obstruction of the common duct; or that, even if a stone cannot be palpated, a dilated common duct is an indication for incision and exploration, especially if there is an associated history of jaundice. Third, the inability of the inexperienced operator to carry out safely such surgical measures as the removal of a soft stone from the ampulla of Vater or stones from the hepatic duct renders it difficult for him to accomplish desired results. Finally, if operative injuries, particularly of the ducts, are to be avoided, experience is essential.

Inexperience is a relative term, for, in all the problems of diagnosis and treatment which can arise in diseases of the gallbladder and ducts, it is impossible for any surgeon to become so efficient that further experience would not at times be beneficial to the patient. The results of gross inexperience, however, will probably be much less in evidence when medical graduates will be required to obtain the necessary postgraduate study before invading special surgical fields, and when hospital standardization reaches the plane on which it should rest. In the meantime, the patient who places himself in the hands of the inexperienced surgeon is fortunate if that surgeon realizes his limitations and does not attempt more advanced surgery than these allow.

Inadequate Exposure.—The master word in the craft of surgery is simplicity (Moynihan). One of the most common mistakes made by surgeons is the failure to appreciate the importance of good exposure in contributing to the simplicity in operation. How frequently may be recalled operations made unnecessarily difficult by a small incision, poor light, and an obscured operative field. Nearly all the serious situations in operations on the thyroid, spleen, kidney, pelvic organs, and so forth, are associated with difficult accessibility. In surgery of the gallbladder, accessibility is sometimes particularly difficult, and the same operative procedure may entail the widest limit of difficulty or facility.

Disastrous sequelae may be directly attributable to inadequate exposure, and we may appropriately refer briefly to the more important means of securing the best possible exposure. A suitably placed incision of sufficient length is essential. In the clinic, we have adopted a modified Bevan incision in the rectus, beginning high in the epigastrium and about 1.25 cm. to the right of the middle line; such an incision gives the most adequate access to any lesion that may be encountered in the gallbladder or ducts. The incision in the skin and subcutaneous tissues should sufficiently exceed in length the proposed opening in the aponeurosis, muscle and peritoneum, so that, should enlargement of the opening in these deeper layers become necessary as the operation proceeds, it would not be necessary to extend the incision in the skin or subcutaneous tissues. A capable first assistant can be of great service in drawing away from the field of operation the hepatic flexure of the colon, the duodenum, and the pyloric end of the stomach. Masson [1] has recently suggested a most useful means of gaining better view and access. He introduces a large gauze pack between the superior and outer aspects of the right lobe of the liver and the diaphragm, so as to swing and rotate the liver downward and forward, gaining in this way not only better access to the gallbladder and ducts, but lessening the excursions of the liver during respiration.

An Operation of Intrinsic Difficulty.—Even with every aid, the difficulties inherent in the individual operation may be considerable because of a fleshy patient, a high-lying liver, inflammatory thickening of the gallbladder, ducts, and pancreas, or adhesions which prohibit a satisfactory exposure. Moynihan has recently stated that he knows of nothing in surgery which approaches in difficulty a cholecystectomy under such circumstances. The conditions may be sufficient to leave doubt in the surgeon's mind as to whether the full extent of the pathologic processes have been determined and dealt with; usually, however,

1. Masson, J. C.: Exposure in Gallbladder Surgery, Ann. Surg. **69**:422-424 (April) 1919.

the subsequent course of the patient shows this fear to be unfounded. There are cases in which failure to deal with the conditions which later are responsible for the continued draining of bile can be fairly attributed to anatomic and pathologic obstacles, and a persisting fistula may also follow an unusually difficult operation on the deep ducts, such as resection for cancer, cyst, or stricture, or a reconstructive operation for existing fistula.

Hurried Operations.—It is hardly necessary to comment on the dangers of a hurried operation. Speed is responsible for many mistakes in abdominal surgery. What appears to a brilliantly executed operation may in reality be quite incomplete through overlooking additional lesions. When operations on the gallbladder are followed by unfortunate sequelae and discreditable results, it is usually because they have been carried out on insufficient indications or because important details have been sacrificed to haste.

Incomplete or Careless Exploration.—A thorough exploration is one of the most important principles in abdominal surgery, and in the abdomen no region demands so much care and efficiency in exploration as does the biliary tract. Every means, inspection, palpation, and instrumentation, should be utilized. If, for example, small nodules are palpated in the line of the cystic duct, and a differentiation of glands and calculi cannot be established with certainty by inspection and palpation, exploration should be continued by splitting the gallbladder down to the opening of the cystic duct, so that by instrumentation it can be determined whether the palpable nodules are within or without the duct. Similarly, when doubt exists concerning the patency of the common or hepatic ducts (occasionally careful inspection and palpation of ducts fails to convince even the most skilled surgeon that the ducts are clear), incision of the main duct and exploration with probe and scoops are imperative. The marked similarity under palpation between cancer of the duct and stone should not be forgotten. Exploration of the pancreas involves difficulties in the differentiation of various degrees of pancreatitis, of the nodular form of pancreatitis, and of cancer. In such cases, particularly if obstructive jaundice exists, a correct differentiation is extremely important, both from the standpoint of operative procedure and from that of prognosis. Fortunately, such differentiation can usually be made at operation.

Uncertainties may remain after most efficient exploration; on the other hand, a most obvious pathologic condition is sometimes overlooked by neglect or carelessness in exploring. Such oversight is doubtless partly due to the assumption that a gallbladder filled with stones is sufficient and satisfactory evidence to support the history, and that the removal of the stones should assure the patient complete relief. A

diligent, routine search for surgical conditions in other portions of the biliary tract is accordingly omitted, frequently to the continued and later disability of the patient. An incomplete operation may thus be, and usually is, the primary cause for a persistent fistula, the most common mistake being failure to remove all the stones from the cystic, common, or hepatic ducts. In this series there were 105 such cases. Rare conditions, such as a ruptured gallbladder with localized abscess and beginning peritonitis, occasionally justify incomplete operation in anticipation of dealing radically with the pathologic process at a later and safer time.

Failure to Remove the Gallbladder.—A contributory factor to postoperative fistula in 90 per cent. of the cases in this series was failure to remove the gallbladder at the first operation; doubtless the removal would have spared these patients the second operation. Comparative statistics of experienced surgeons show that cholecystectomy has a decided superiority over cholecystostomy in every respect, operative mortality, immediate and late results, and biliary function.

Accidental Injury to Ducts.—Under this heading may be included the most serious conditions with which the surgeon has to deal. In several recent articles the common types of such injuries, the causes of their occurrence, and suggestions for their avoidance have been discussed. The most important injury is division, crushing, or resection of a portion of the common or hepatic ducts. The chief cause for such accidents in cholecystectomy lies in failure accurately to identify the cystic duct. The various anomalous relations which the cystic duct may hold to the hepatic and common ducts may easily lead to damage of the deeper ducts if the cystic duct is not carefully isolated before it is clamped and divided. Careless or hurried attempts to grasp a bleeding cystic artery (especially, if it has retracted into a position close to the hepatic duct) may result in clamping and ligating the hepatic or common duct.

Unintelligent Use of Drains.—In no case of the series was there clear proof that the pressure of a drain was solely responsible for the fistula. It is quite conceivable, however, that conditions productive of fistula could be brought about by gauze becoming adherent to the wall of the common duct already injured by pressure of a stone, or by forceps. One case illustrates the fact that drainage, prolonged far beyond the reasonable time, may be sufficient to establish a permanent drainage tract. The tendency of late is to use less and less drainage in surgery of the gallbladder and ducts, and, indeed, in general abdominal surgery. In selected cases of cholecystectomy drainage may be safely omitted. In 286 cases observed during the last three years the results of such procedure have been satisfactory.

Reformation of Stones.—Finally, in those cases in which the fistula closes for a varying time after operation and then reopens, the formation of stones must be mentioned as a possible factor, and in some instances apparently as the sole factor. In Table 1 is given the average length of time fistulas had been present in the various types of cases, the average varying from four and one-half months in cancer of the pancreas to thirty-seven months in cases of "stones in the gallbladder." Why such a difference of time should exist in these groups is readily understood. It is not easy to explain, however, since the question is chiefly one of the reformation of stones, why such long periods intervened in some cases before the reopening of the fistula which had closed normally after operation. It may be accepted that stones can remain in the gallbladder many years without producing sufficient obstruction to reopen the drainage tract to the surface; but it is difficult to believe that a stone could remain long in the common duct without sufficiently raising the pressure of bile to divert it through its former external communication, or to cause symptoms sufficient to indicate its presence or to necessitate operation. Available evidence supports the view that when the original operation is thoroughly carried out, actual reformation of stones in any portion of the biliary tract is exceedingly rare, but it may occur in the gallbladder, or in a common duct even if the gallbladder has been removed. The tendency to the reformation in the common duct is greater in cases in which there has been long continued dilatation and infection from an obstructing calculus. Following the removal of such a stone, the duct may become plugged with a soft type of pigmented stone which does not contain cholesterin, and a secondary operation becomes necessary within a few months. In three cases such stones have reformed a third time, and have been removed. A cure finally resulted in all.

Although it is seldom possible to attribute definitely the conditions which produced the fistula to any certain one of the causes which we have just discussed, it should be emphasized again that in only sixteen cases in the entire series had the gallbladder been removed at the original operation, and, exclusive of the cases of operative injuries to ducts, in only three cases had cholecystectomy been performed.

INDICATIONS FOR SURGICAL INTERVENTION

The indications for the operative repair of a fistula depend to a large extent on the length of time the fistula has been draining, on its behavior from day to day, and on the cause and probability of its persistence. It is fortunate that there is no objection to allowing ample time for a fistula to close spontaneously. The general health of the patient is not seriously disturbed, nor is the operation made more difficult by continued drainage, so that the hope that it will cease of itself justifies postponement of operation for a reasonable time.

When some portion of the biliary tract has been left open, such a wide variation exists, under normal conditions, in the duration and quantity of drainage that unnecessary apprehension is sometimes occasioned by continuance of drainage much beyond the usual time limits. The reason for such variation has not been determined. Apparently, it does not depend on the operation, for in choledochostomies, for example, after the tube in the common duct has been removed, bile drainage ceases immediately in some cases, and in others lasts for days. A probable reason for such variability may be found in the character of sphincteric control at the ampulla. Because of such normal variability, no very definite time limit can be laid down as a basis on which to determine the wisdom of surgical interference. A study of the postoperative records of the Mayo Clinic, however, shows that bile drainage rarely persists beyond three weeks after the last drains have been removed. If, at the end of that time, a large quantity of bile is continuously draining through the incision and only a small amount is entering the intestine, it may well be suspected that some mechanical obstruction exists, and that this obstruction will not of itself disappear.

In cases in which the drainage entirely ceases and then reappears, recurrence of discharge is frequently preceded by attacks of pain and jaundice, with possibly chills and fever, all of which disappear after the drainage tract reopens. Recurring fistulous activity, accompanied by such signs and symptoms, is almost a certain indication of obstruction of the common duct by a ball valve stone.

It should not be forgotten, however, that obstruction of the common duct by cancer of the head of the pancreas may be temporarily and sufficiently relieved to permit passage of bile into the intestine, with consequent closure of the fistula for a short time. The alternate closing and opening of a fistulous tract may also be a manifestation of stone obstructing the cystic duct or the pelvis of the gallbladder. In such cases, the signs and symptoms preceding reactivity are limited to pain, local soreness, and possibly a tender palpable gallbladder, while a discharge of mucus, possibly slightly tinged with bile, is further definite evidence that the gallbladder is shut off from the remainder of the biliary tract.

What length of time external drainage of bile may continue without evident effect on the general health of a patient is an interesting question. In this series the longest reported period that a fistula had existed was eleven years; in this instance all the bile had not been diverted to the surface. The longest time during which all of the bile drained to the surface was three years. In this case, at the third operation, four stones, each about 3 cm. in diameter, were found in the common duct. Following a cholecystostomy elsewhere three years previously, bile had

drained copiously and the stools had almost continuously been clay-colored. A tube had been in place for two years. There was no jaundice: the hemoglobin, however, was only 35 per cent. at the time of the operation. The patient showed neither definite disturbance in gastro-intestinal function nor recognizable nutritional disorder other than anemia. In another patient with stone in the common duct, apparently all the bile drained to the surface for eighteen months. The longest periods of drainage in cases of injury to the duct were twenty-one months and twelve months (Table 3).

TABLE 3.—PROLONGED DRAINAGE OF ALL BILE TO THE SURFACE
(Thirty-Four Cases)*

Causative Factors	Cases
Stone in the common duct	10
Division of the common duct	12
Stricture of the common duct	6
Carcinoma of the pancreas	3
Chronic pancreatitis	2
Stone in the hepatic duct	1

Average duration of complete fistula, seven months.
There was a total of ninety-three operations in this group (here and elsewhere, including primaries).

* It is obviously difficult to establish absolute evidence of complete fistula (all bile). The evidence was carefully considered and only those cases that were fairly certain were included.

Preoperative diagnosis is always desirable, and we have already indicated some of the points on which a diagnosis may be established. In certain cases, especially when malignancy is suspected in the pancreas or in the duct or liver, a preoperative diagnosis is essential to the best interests of the patient. In cases of doubtful diagnosis, operation may well be deferred since the further course of the disease will settle the question. Sometimes the history of symptoms leading up to the original operation, in particular, the development of painless jaundice, associated with steady, progressive emaciation, together with the findings reported at operation, will give reasonable certainty to a diagnosis of malignancy and will justify advice on that assumption. If it is known that the common or hepatic duct has been injured, or if injury is suggested by a history of repeated operations, the surgeon must decide whether he should undertake one of the most difficult of all abdominal operations, namely, restoration of biliary function by reconstruction of the ducts.

SURGICAL TECHNIC

The operative management of biliary fistulas varies within wide limits. The cure of gallbladder fistula by removal of a stone impacting the cystic duct is quite simple and satisfactory. On the other hand, nothing can exact more surgical ability and experience than an attempt to restore the normal course of bile after several previous efforts have been made to repair the ducts.

By avoiding adhesions in the field of the former operation, it is surprising how much the operation for repair of a fistula may be simplified. This is accomplished by placing an incision beginning in the costosternal angle well to the median side of the former incision and the site of the discharge. Such an incision gives also much more direct access to the biliary ducts, which, regardless of preoperative findings, must always be thoroughly explored. The advantage of approach to the common duct through the upper end of such an incision is so great that, even though several prolonged operations to discover the cause of the fistula have previously been performed, a common duct stone may often be located and removed with ease. Location and removal of overlooked calculi, which are the commonest single cause of persistent fistulas, can easily be effected without much difficulty. If the gallbladder has not been removed, its early separation from the abdominal wall will facilitate the exploration and the steps of the operation. Before a complete examination of the operative field has been made, the gallbladder should not be removed, for it serves a most valuable purpose when irreparable damage has been done to the common duct, or when there is malignancy in the duct or pancreas. Further, if it seems likely, but not certain, that a permanent and satisfactory repair can be made of a strictured common duct, the conservation of the gallbladder anticipates a possible recurrence of stricture in the duct, and, by means of subsequent anastomosis, provides a way for the diversion of bile to the gastro-intestinal tract directly through the gallbladder. When such an anastomosis becomes necessary, the stomach or duodenum may be made use of equally well. With the exception, then, of a very few cases in which the preservation of the gallbladder is justified for reasons mentioned, the organ should be removed because of its disposition to cause future trouble.

A satisfactory method of cholecystectomy, such as that described by Judd,[2] should include as its most important feature the accurate identification and isolation of the cystic duct. When the gallbladder has been previously removed, its usefulness as a guide in operation will be missed. In ordinary cases, however, the absence of the gallbladder is not of consequence, for as a guide its place is well taken by the gallbladder notch of the liver.

In a patient who has already had the gallbladder removed, who has had one or more reconstructive operations on the ducts, and who suffers from chronic jaundice with its attendant liver and blood changes, the repairing of a biliary fistula due to an extensively damaged or excised common or hepatic duct offers the most difficult situation which may

2. Judd, E. S.: Surgery of the Gallbladder and the Biliary Ducts, J. A. M. A. **71**:79-82 (July 13) 1918.

confront a surgeon. Experience in the Mayo Clinic has demonstrated that the most satisfactory method, and in many instances the only method, of dealing with such cases is to make a direct anastomosis between the hepatic duct and the duodenum. This method, the principles of which were first described by W. J. Mayo in 1905,[3] is so successful that the operation of hepaticoduodenostomy can be regarded as serving the same excellent purpose as cholecystogastrostomy or cholecystoduodenostomy when the gallbladder is present. The technic of hepaticoduodenostomy, at present preferred and practiced in the clinic, has been described in a recent paper.[4] The method is characterized chiefly: first, by the use of a duodenal flap (as originally advocated by Walton [5]), which is wrapped around the posterior aspect of the stump of the hepatic duct, thus forming a trough for the duct; second, by a large opening in the duodenum, and third, by the consequent closing of the duodenal opening by fixation to the capsule of the inferior surface of the left lobe of the liver. The large duodenal opening and the manner of closing it prevents subsequent contraction on the end of the duct, with the intermittent or chronic jaundice which so frequently complicated former methods of uniting the hepatic duct and duodenum. When direct union of a severed common duct, or excision of a stricture, neoplasm, or cyst of the duct, is necessary, one of the methods described in detail by Eliot [6] may be employed.

RESULTS

In this series of operations in 166 cases of biliary fistulas there were sixteen deaths, a mortality of 10 per cent. In operations undertaken for various conditions which were responsible for fistulas, the percentage of deaths shows very clearly the relative risks which accompany these operations. For instance, in thirty-five cases of stone in the cystic duct, no operative mortality occurred, while in the groups "division of the common duct" and "stricture of the common or hepatic ducts," six deaths in twenty-one cases were due largely to chronic jaundice and sequelae so common in such cases. The general rate of 10 per cent. mortality for the entire group is unfortunate when compared to that of from 1 to 2 per cent. which accompanies adequate

3. Mayo, W. J.: Some Remarks on Cases Involving Operative Loss of Continuity of the Common Bile Duct, Ann. Surg. **42**:90-96, 1905.

4. Balfour, D. C.: The Technic of Hepaticoduodenostomy with Some Notes on Reconstructive Surgery of the Biliary Ducts, Ann. Surg. **73**:343-347 (March) 1921.

5. Walton, A. J.: Reconstruction of the Common Bile Duct, Surg., Gynec. & Obst. **21**:269-275, 1915.

6. Eliot, E., Jr.: The Repair and Reconstruction of the Hepatic and Common Bile Ducts, Surg., Gynec. & Obst. **26**:81-102 (Jan.) 1918.

primary operations on the gallbladder and ducts. Ten per cent. mortality can, however, not be looked on as excessive for a group of cases so frequently presenting such serious surgical complications. In considering ultimate results, the first question, of course, is, What degree of success has attended the primary purpose of the operation, the closure of the fistula? Of the eighty-three living patients from whom we have been able to secure positive information, eighty (98 per cent.) have been completely relieved of fistula. The health of patients who have reported is generally good, exceptions being chiefly confined to patients undergoing reconstruction operations on the deeper ducts. Of the entire series of patients, twelve reported occasional attacks of pain and jaundice; these were distributed as follows: "stone in the common duct," five; "stone in the cystic duct," two; "division of the common duct," two; "stricture of the common duct," two, and "stricture of the cystic duct," one. As a final observation, it may again be noted that, exclusive of the thirteen cases of duct injuries, in only three of the remaining 153 cases had the gallbladder been previously removed.

This review of the series of 166 cases of postoperative biliary fistula has shown: (1) the variety of conditions which may be responsible for a persisting fistula; (2) the more common causes for the presence of such conditions; (3) the duration of some fistulas; (4) the surgical management of fistulas, and (5) the excellent results obtained by radical surgical measures.

THE SUSPENSION TRACTION TREATMENT OF FRACTURES OF THE LONG BONES NEAR LARGE JOINTS*

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The underlying principles which make for efficiency in the suspension traction treatment of fractures of the long bones are now well understood. Foremost among them is that this form of treatment takes into full consideration the necessity of caring for the damaged soft parts. Full recognition is given to the truth that in many instances muscular, fascial and joint repair are far more important in restoring a properly functioning limb than absolute anatomic restitution of the bone. This form of treatment also accepts the truth of the teaching of Lucas-Championnier, that complete fixation of fragments is not necessary for proper callous formation, in fact, may be detrimental to it.

In addition to these, the traction suspension treatment affords the best means of placing the distal fragment in proper alinement with the proximal fragment. In every fracture of a long bone, two elements enter into the resulting deformity. Either a proximal fragment is drawn from the planes of anatomic rest, while the distal fragment assumes such position, or the distal fragment is drawn out of the planes of the normally placed proximal fragment. Not infrequently, these two elements are combined. As a rule, the first effect is more marked when the fracture line lies near the proximal end of the bone, while the second is more prominent when the fracture line lies near the distal end. Almost universally, the surgeon has better control over the distal than the proximal fragment. Therefore, treatment aims so to place the traction suspension forces that the former is drawn into proper alinement with the latter. Occasionally, it is helpful to supplement this with traction applied to the distal end of the proximal fragment. Our means for doing this are, as yet, not over adequate; but I am inclined to believe the method of Heitz-Boyer can be made to find a wider application than it has enjoyed.

It is my belief, that with proper attention, practically every fracture through the middle third of a long bone can be successfully treated by the traction suspension method, and that the results will be more promptly obtained and better functionally than by other methods. In other words, I have found the principles of this method sound and

* Read before the American Surgical Association, Toronto, June 14, 1921.

their application possible with this type of fracture. It must be emphasized, however, that the application is often beset with difficulties, and that patient, untiring effort will alone be rewarded with success. It is a method that can be applied only after considerable experience, and with attention to detail that many surgeons are unwilling to give. Its success, therefore, depends on the opportunity to see and treat a considerable number of cases, coupled with a recognition of the fact that the expenditure of time and care will bring a satisfying reward. The hospital service—Cornell Division of Bellevue Hospital—where our study has been carried on, furnishes in abundance the former, and has been fortunate in having on its staff two men (Dr. Kenneth Bulkley and Dr. James Worcester) who have furnished the latter, and by their enthusiasm, inculcated their confrères with the desire to continue the work.

Fig. 1.—Dr. Worcester's modification of tongs, with blunt conical points to prevent too deep penetration.

As a result of our experience, I repeat that only very exceptionally do we encounter a fracture in the middle third of a long bone which cannot be successfully treated by the traction method. Every fracture is made an emergency case in that its treatment is immediately undertaken on admission. A preliminary roentgenogram is taken. The method of applying traction in fractures of the femur is by means of the ice tongs, as modified by Dr. Worcester (Fig. 1), and suspension is obtained by the Thomas splint and the Balkan frame (Fig. 3). In an adult male, the initial weight applied is 25 pounds or more. This is reduced when the roentgenogram indicates that it is possible. It cannot be overemphasized that the immediate application of sufficient weight to overcome the shortening is all important. Over pull is preferable to under pull. Too little weight at first results in a fixation

of the injured muscles in a shortened condition, and necessitates later a far greater weight than would have been initially needed. The suspension is done in the recognized way, so that active and passive motion (by means of pulleys) of both the hip and knee are at once begun. In humeral fractures, the traction is obtained either by adhesion to the skin or by means of the Henniquen band around the flexed elbow. From 5 to 8 pounds is sufficient, and either method will support this without difficulty. The suspension is by means of a specially constructed addition to the Balkan frame, which permits traction at any angle with the trunk (Fig. 4). Fractures in the shaft of the leg are usually drawn into direct alinement without difficulty. Occasionally, however, badly comminuted fractures show a persistent deformity which can

Fig. 2.—Tong points too tapering. They penetrate too deeply.

be readily overcome by tong traction on the malleoli or os calcis, or by the Henniquen band if low, or skin traction if high. Our success with the Sinclair skate has not been satisfying.

What has been stated concerning our satisfaction in this method of treating fractures through the middle third of the long bones, cannot be said with the same degree of satisfaction concerning fractures near the large joints. However, our experience here leads us to believe that further study will overcome the difficulties we have encountered, and we are satisfied that in the end such fractures will yield a higher percentage of good results by this method than by any other.

It must emphasized that a perfect anatomic repair of a bone, accompanied by a badly crippled joint, is far more disturbing to the

patient than a poor position of the fragments with a well functioning neighboring joint. In many cases a proper reposition of the fragments has in my hands proved impossible. Nature, however, has responded more than satisfactorily in her ability to reestablish a range of motion in the joint which permits of all essential activities.

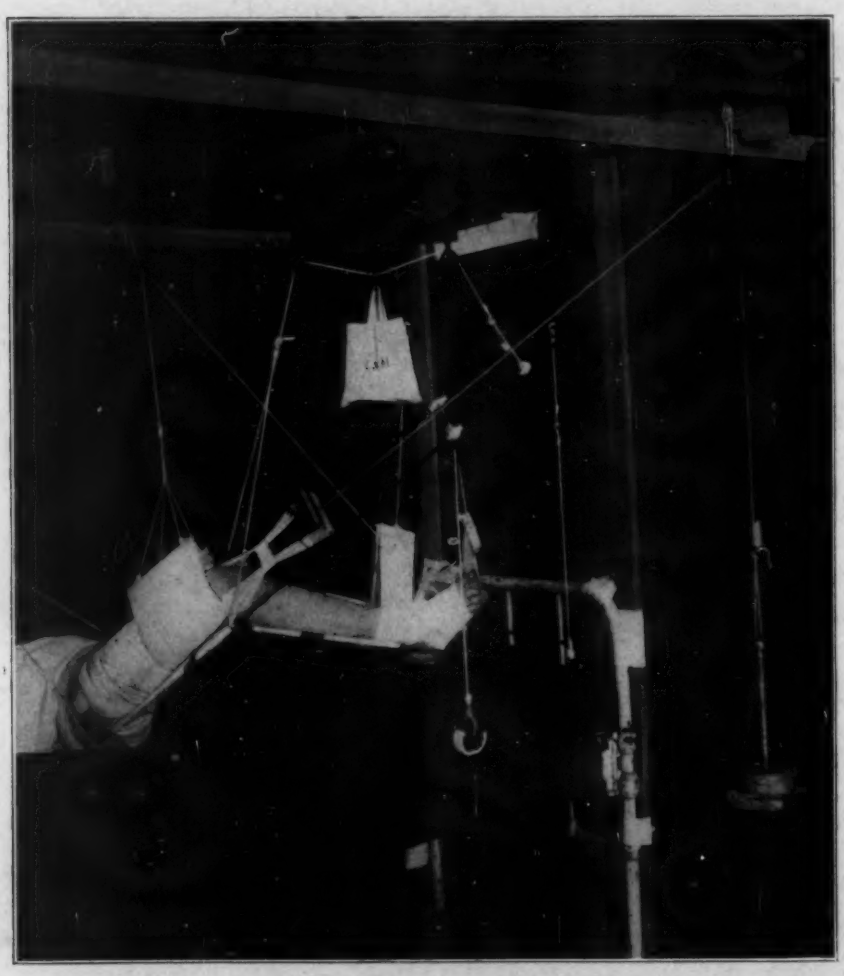

Fig. 3.—Suspension in Balkan frame for a high fracture of the femur with skin traction, illustrating outward rotation, abduction and leg flexion splint attached to the Thomas splint. When only moderate traction is needed, it can be obtained by skin adhesion on the thigh, still allowing knee movements.

Fractures near the hip, the knee, and the shoulder have received the most attention.

When the femur is fractured somewhat below the tuberosities, the upper fragment usually assumes a more or less constant position of

external rotation, and abduction, by reason of the stronger group attached at the greater tuberosity, and of flexion because of the direct pull on the lesser trochanter. The extent of these forces varies greatly according as the fracture is near or removed from the line of the tuberosities. If placed some inches distant, so that some fibers of the

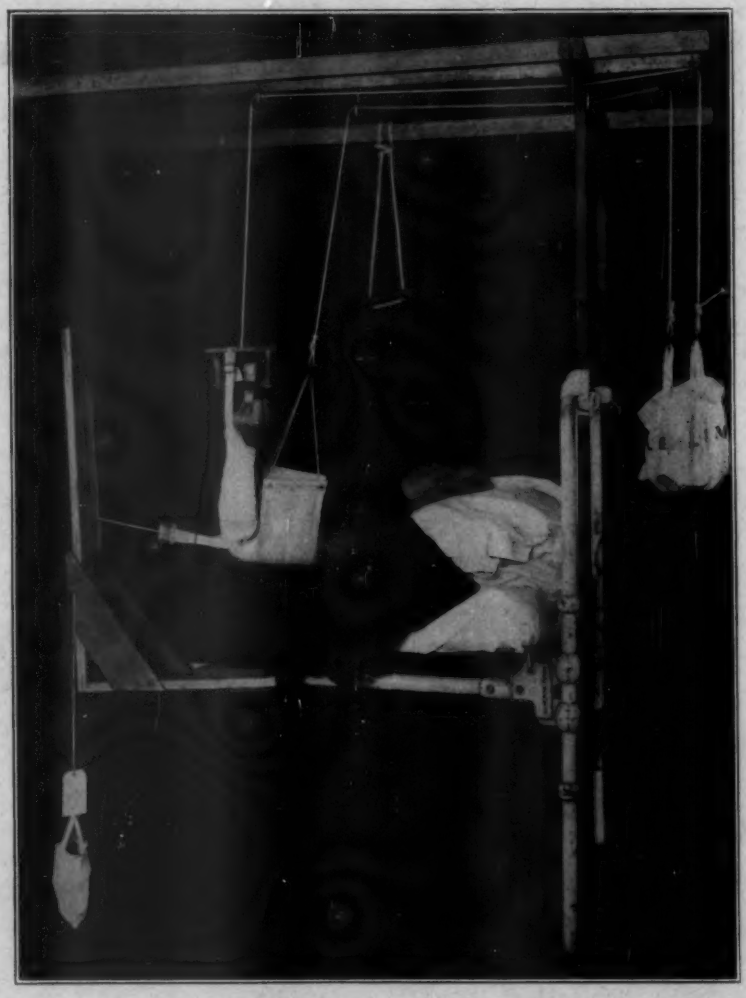

Fig. 4.—Traction of arm in only slight abduction. The amount of abduction is modified as needed by means of the hinge between the mattress board and the horizontal board. The elbow is lowered or raised by the movable pulley attachment within the slot on the vertical support.

abduction group remain attached to the upper fragment, this portion of the femur may be drawn into abduction, and neither external nor internal rotation is present. Moreover, in some instances, the fracturing

violence may cause unusual positions of the fragments, at the time of injury. The fractured ends having penetrated deeply into the muscle and fascial structures are prevented from taking up the positions

Fig. 5.—Subtrochanteric fracture without either abduction or external rotation of the upper fragment. This fragment is held in slight adduction by the pull on the adductors exerted by the lower fragment being drawn well upward and inward. The fracture was caused by violence applied directly to the external aspect of the femur at the point of fracture, with sufficient force to displace it well inward.

resulting from the abnormal muscle pull alone. We have thus come to learn that one may not rely on a knowledge of muscular action only to predicate the position of the fragments even in such classical

fractures as subtrochanteric or those through the surgical neck of the humerus. Dependence must, in the last analysis, be placed on the roentgen ray, and, therefore, the treatment of fractures can be carried out properly only when a bedside apparatus is continuously available.

Fig. 6.—Same fracture as in Figure 5, twenty-four hours after applying tong traction of 25 pounds. The overriding is corrected; but the upper fragment is still adducted.

These points are all well illustrated in the case of a woman, aged 60, who, in a street fight, was knocked down and jumped on by another woman (Fig. 5). The violence was applied mainly to the upper right thigh. Admission to the hospital was three days after the injury. There was an obvious fracture about 3 inches below the trochanters,

with overriding of 2 inches. The upper end of the lower fragment was displaced inward and slightly anteriorly as might be expected. The upper fragment, however, was also adducted, and in normal rotation. A study of the condition, both by palpation and the roentgen

Fig. 7.—Same fracture as in Figures 5 and 6, showing better alinement which was obtained by placing the limb in adduction, with lateral counter pull by a sling placed around the upper end of the lower fragment.

ray, showed that the upper fragment was held in this position because of the pull of the torn adductor muscles, which were tightly stretched over the lower fragment. The latter, by the direct violence of the injury, had been forced inward and dragged the upper fragment with it.

An attempt to place such a fracture into proper alinement, by abduction of the limb with traction suspension, failed. A satisfactory position was obtained only by tong traction of 25 pounds applied above the condyles, with the limb suspended in adduction and some flexion.

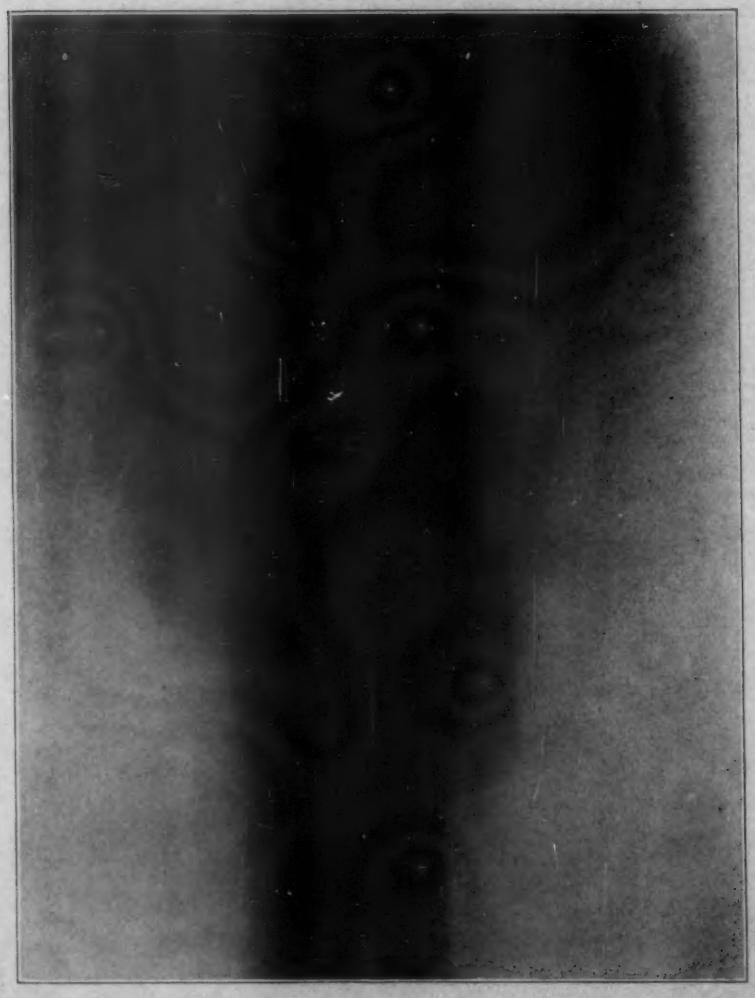

Fig. 8.—High spiral fracture of femur together with fracture through the lesser trochanter; upper fragment rotated outward and abducted; satisfactory result obtained by the treatment shown in Figure 2. In such cases only moderate traction is needed.

Even though there was a delay of a week from the time of injury before this was done, the overriding was entirely reduced in forty-eight hours (Fig. 6), whereas five days of skin traction had completely failed.

After correction of the shortening, there was still inward displacement of the upper end of the lower fragment which could be corrected only by direct outward pull by means of sling and pulleys.

The functional result in this patient was most satisfactory. Movement at all joints was practically normal; union was firm, and the anatomic deformity in the bone could be known only by means of the roentgen ray. In consideration of her age, 60 years, her alcoholic habit, and the presence of Paget's disease, she continued to use an ambulatory splint for eight months.

It was this case which first emphasized the necessity of recognizing that dependence cannot be placed on muscle pull alone

Fig. 9.—Pertrochanteric fracture.

in determining the position of the fragments. Several days were wasted in an attempt to place the lower fragment in line with an upper fragment erroneously presupposed to be abducted.

A contrast to this case is shown in Figure 8. The fracture is higher, the lesser trochanter being attached to the lower fragment, and the line of fracture is spiral. The upper fragment is in marked abduction and outward rotation, the classical deformity. Suspension, tong traction of 25 pounds immediately after receipt of injury, reduced to 15 pounds after only twenty-four hours, and replaced by skin traction after four weeks, was the treatment used. The limb was placed in 45 degrees abduction, moderate flexion, and extreme external rotation. The knee was flexed to 45 degrees on a movable leg attachment to the Thomas

splint. There was complete union, with full motion at all joints, at the end of two months. The patient was up in a chair for a month longer and then discharged wearing a Thomas caliper splint. He has failed to report at the follow up clinic; but there can be no doubt of an excellent result as judged by the condition on discharge.

Fig. 10.—Dr. Rogers' attachment to wheel chair for carrying out all the requisites of traction suspension treatment. This should be used only when union is nearly complete and when only moderate traction is needed.

Our experience with the suspension traction treatment of fractures in immediate relation to the hip joint, either through the trochanter or of the neck proper, has not been extensive. It is sufficient, however,

to convince us that excellent results may be obtained with the former, and we can find no reason to believe that the latter also will not respond favorably.

A pertrochanteric fracture, involving the distal end of the neck, was received by a man, aged 36, when he fell down-stairs. He was immediately admitted to the hospital with the typical disability and deformity of this condition (Fig. 9). Treatment was by suspension in

Fig. 11.—Fracture through neck of femur, showing functional result after three months' treatment in traction suspension, with 15 pounds skin traction.

flexion, outward rotation, and 45 degrees abduction. The knee was placed in 45 degrees flexion on a movable leg attachment to the Thomas splint. Skin traction was used to the amount of 15 pounds for six weeks, and then reduced to 10 pounds. The patient was allowed to be up in a wheel chair with a Thomas splint attachment for suspension and traction (Fig. 10), devised by the resident surgeon, Dr. William

A. Rogers, for ten weeks longer. He was then discharged wearing the caliper splint. He reported six months after receipt of the injury, when the following condition was noted: "The patient walks normally. No limp. Has no pain in hip, but states that the knee becomes stiff when he doesn't use it. After walking a little, it is all right. The caliper brace was removed five and a half months after receipt of the

Fig. 12.—Fracture through neck of femur, showing functional result after three months' treatment in traction suspension, with 15 pounds skin traction.

injury." Complete restoration to a normal working condition, therefore, was present in this case in less than six months. The absence of muscular atrophy and joint disability is a noteworthy concomitant of this form of treatment as compared to its prevalence in complete fixation with plaster cast.

As stated, our experience in similar cases is limited; but there have been no failures, and the consensus of opinion of the staff is that the results are far more satisfactory than with fixation methods, and that the patients are, on the whole, far more comfortable.

A typical fracture of the neck of the femur is shown in Figure 11, and the outcome at the end of three months is shown in Figure 12.

Fig. 13.—Fracture of surgical neck of humerus, with the greater tuberosity completely avulsed. The upper fragment is turned so that the fracture line looks almost inward. This is hardly possible if the tuberosity remains attached to the proximal fragment. This patient was operated on with fair success.

This fracture was treated throughout with suspension traction in marked abduction and external rotation. Skin adhesion was used, and movements in the hip and knee were carried out from the first. The

result, after six months, was an entirely normal hip so far as weight bearing and range of motion were concerned. The roentgenogram showed a moderate coxa vara.

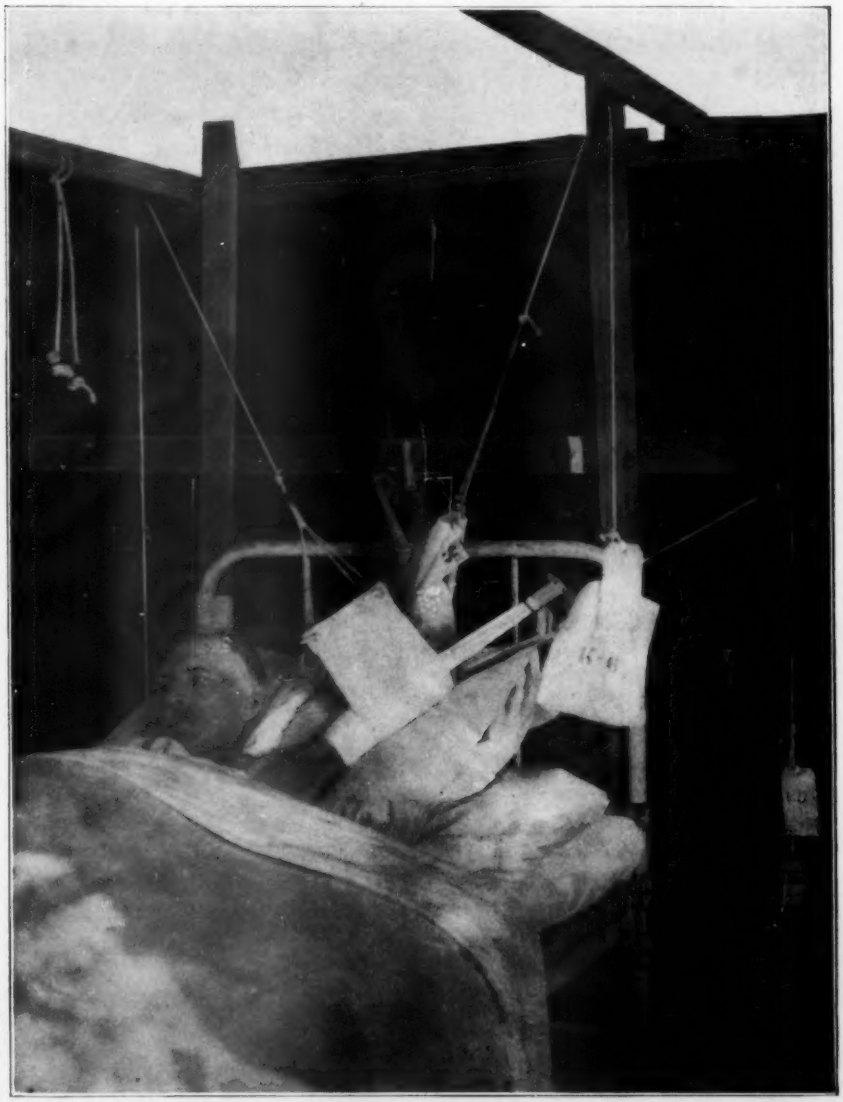

Fig. 14.—Extreme abduction and external rotation needed to procure proper alinement when a surgical neck fracture allows this exaggerated position of the proximal fragment by pull on the greater tuberosity.

Fractures in and about the shoulder joint show many similarities to those occurring in the upper end of the femur. The essential difference, however, in obtaining a satisfactory functional result is that the

range of movement in the shoulder is all important, while weight bearing without shortening is the prime consideration at the hip. For this reason, treatment of high fractures of the humerus must aim to procure union with the fragments so placed that joint obstruction will not take place and that muscular action may be efficient.

The usual deformity which results from a fracture through the surgical neck of the humerus is abduction and external rotation of the upper fragment. There are many exceptions, however, due to various causes. The most common is a coincident tearing off of the greater

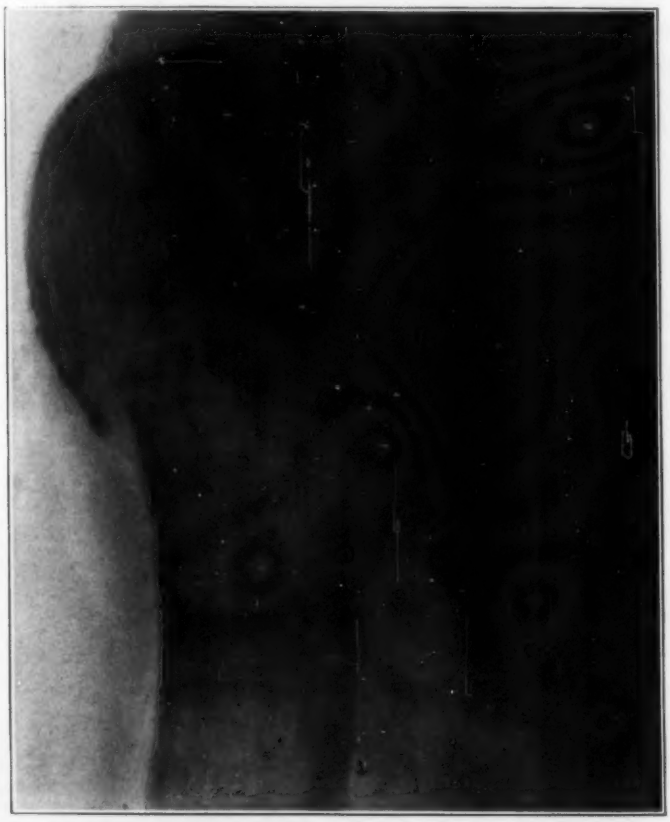

Fig. 15.—Upper fragment in surgical neck fracture is not abducted or rotated, because, as we believe, the muscular attachments are torn away without actual separation of the tuberosity. This fracture was at first treated in slight abduction and later full abduction and external rotation (Figures 4 and 14 are examples) with excellent result and full restoration of function.

tuberosity. This leaves the upper fragment uninfluenced by the muscles attached to this prominence, and it may assume any position, even to an amount of rotation inward so that the fractured surface faces

the glenoid fossa. Such a complete reversal results in leaving the upper fragment beyond control, and so far as we have determined, nothing can be accomplished by traction suspension in changing its position (Fig. 13). Open operation seems a necessity. On occasion, however, the inward displacement is not so complete, and then by placing the humeral shaft in the proper amount of abduction, the fragments are

Fig. 16.—Variations in position in fracture of surgical neck with tearing away of muscles from greater tuberosity.

well alined. After from ten days to two weeks, there is sufficient union to cause the upper fragment to follow the arm as the abduction is increased from day to day. Finally, there is a hyperabduction and external rotation, which then brings the upper fragment in contact

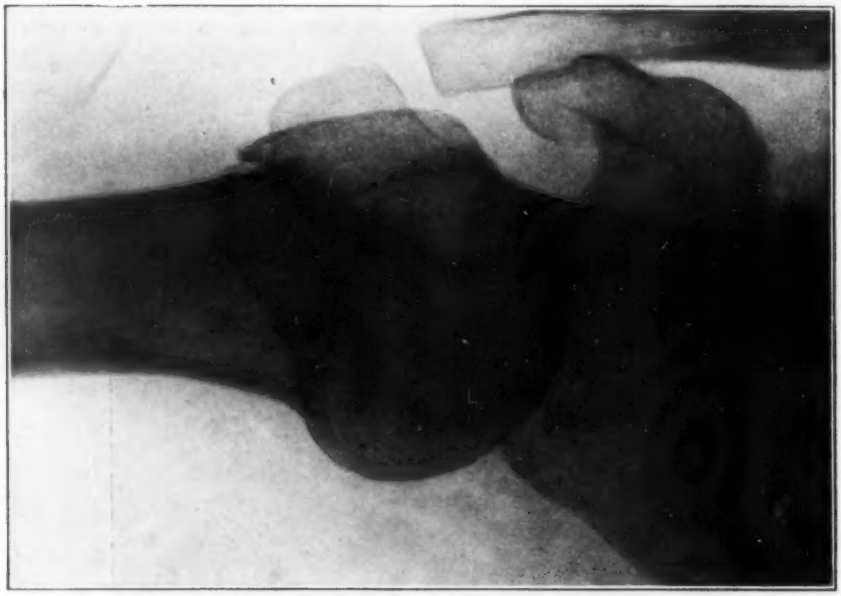

Fig. 17.—Variations in position in fracture of surgical neck with tearing away of muscles from greater tuberosity.

Fig. 18.—High spiral and comminuted fracture of the humerus, in abduction after partial union is established. The proximal fragment was drawn inward by pectoral major fibers.

with the abducted and externally rotated greater tuberosity. Union then results. On recovery the arm falls by gravity to adduction and internal rotation, by which the abduction and external rotation group are drawn out to their normal length, and hence can again function. It is important that some movement should be made in the arm constantly. The

Fig. 19.—Fracture near knee joint, with the lower fragment forward. Flexion of knee exaggerated this deformity while extension corrected it. This and Figure 20 represent the same angle and amount of traction (25 pounds) by tong attachment.

traction suspension treatment ideally furnishes an opportunity for this. Ten pounds is usually sufficient, applied by means of skin traction. The needed modifications in position are obtained by means of the support (Fig. 4) and direct traction (Fig. 14).

One must further recognize that inward rotation of the upper fragment may take place when the muscles or the periosteum are torn from the greater tuberosity without actual separation of the tuberosity itself. This injury need not show in the roentgenogram, though in some cases the periosteal stripping can be seen (Fig. 15). The impor-

Fig. 20.—Fracture near knee joint, representing the same angle and amount of traction (25 pounds) by tong attachment as Figure 19.

tance of this is found in the fact that unless the inward rotation is recognized, the arm may be easily placed in too great abduction. We have fallen into this error on one or two occasions.

Here again, when the fragments are sufficiently adhered, it is necessary to increase the abduction from day to day, so that the greater

tuberosity may be brought into contact with its separated and contracted muscular insertions.

Finally, the fracture of the surgical neck may run obliquely down the shaft so that portions of the pectoral major are attached to the upper fragment. This condition, with entanglement of the fragment

Fig. 21.—Late result: some deformity, but fair movement in the knee joint.

ends in this muscle and the deltoid or arm muscles, may produce bizarre positions.

The important consideration, therefore, is to obtain accurate information as to the position of the upper fragment, by means of the roentgen ray—no other examination will give this—and place the distal fragment by traction suspension in proper alinement with it. Ultimately,

however, the extremity must be brought into complete abduction—sometimes hyperabduction—and external rotation. During healing, a certain amount of active motion must be carried out, this being facilitated by proper counterpoising, so that the entire weight of the limb does not fall on the muscular pull.

Fig. 22.—Late result: some deformity, but fair movement in the knee joint.

The service has afforded many examples of these fractures, all of which have been treated along the lines here described. The functional results have been, without exception, excellent.

This form of treatment, of course, requires confinement to bed for a period of about four weeks. This is not too great a price to pay

for the obtaining of a thoroughly useful shoulder. Examples of these fractures are given in Figures 11 to 18, and the methods of obtaining the needed positions are illustrated in Figures 4 and 14.

Fractures of the femur near and involving the condyles present peculiar difficulties. The typical supracondylar fracture, with the lower

Fig. 23.—Fracture treated by suspension and traction by tongs in the os calcis, with excellent result.

fragment drawn directly backward, can easily be drawn into proper alinement by placing the tongs sufficiently far back and high enough to draw this fragment forward. This is accomplished by so arranging the supporting pulley that the line of traction is 45 degrees or more upward. The fulcrum then comes at the line of the condylar surface

against the patella and its ligament. This is made more efficient by flexion of the leg, and in the first days movements in this joint may be only minimal. After some days, however, the alinement can be maintained even when the leg is moved through a considerable arc. When, however, as illustrated in Figure 19, the lower fragment, by the fracturing force, is driven forward, while the upper fragment lags behind,

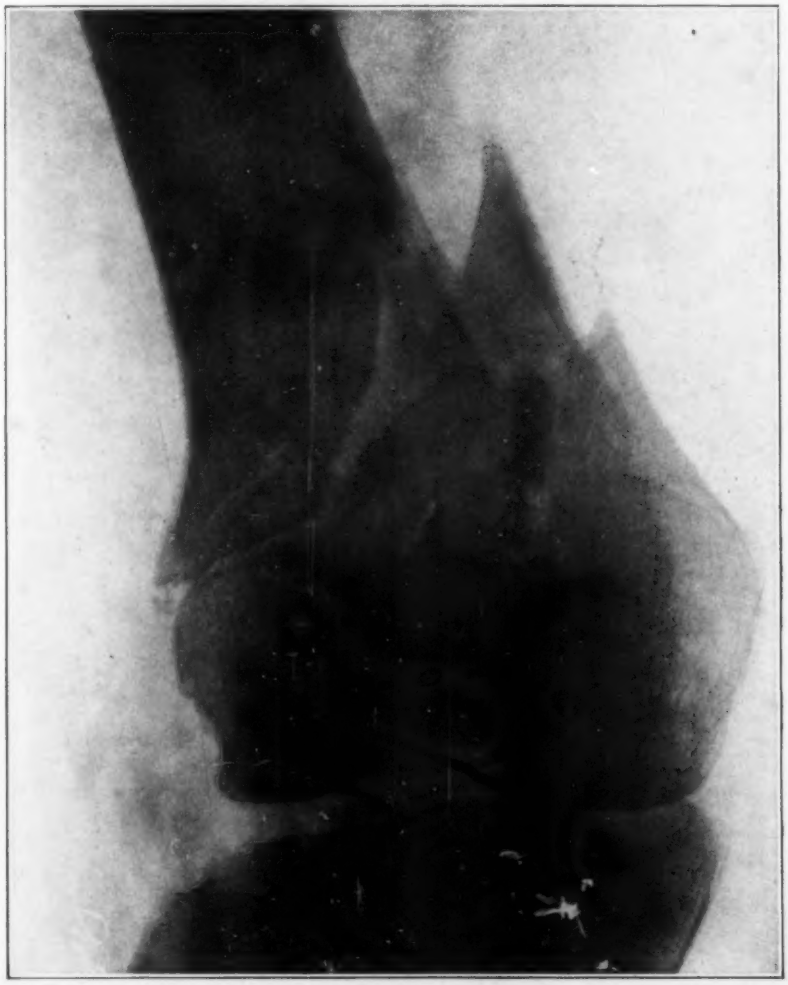

Fig. 24.—Comminuted fracture about femoral condyles, treated by suspension and traction on Steinmann pin through tibial head, for five weeks, with leg extended. Active motion on movable leg attachment then instituted.

we have been able to get proper alinement only by keeping the leg in extension. To do this sacrifices one of the great advantages of the method of treatment, namely, active movement. One must, therefore,

determine in each case whether the wise course is to obtain good alinement without active motion in the knee, or accept some deformity with a good functioning knee joint. In the case above cited, a middle course was followed with a fairly satisfactory result (Figs. 21 and 22), though the fracture was compound, with almost complete rupture of the quadriceps at the site of fracture.

Fig. 25.—The result.

The badly comminuted and displaced fractures involving the femoral condyles and knee joint present unusual difficulties. As a rule only moderate traction is needed; but the problem of securing this, and, at the same time of permitting knee movement, must be solved. Figure 24 shows such a fracture in a woman, aged 60 years, received by a fall

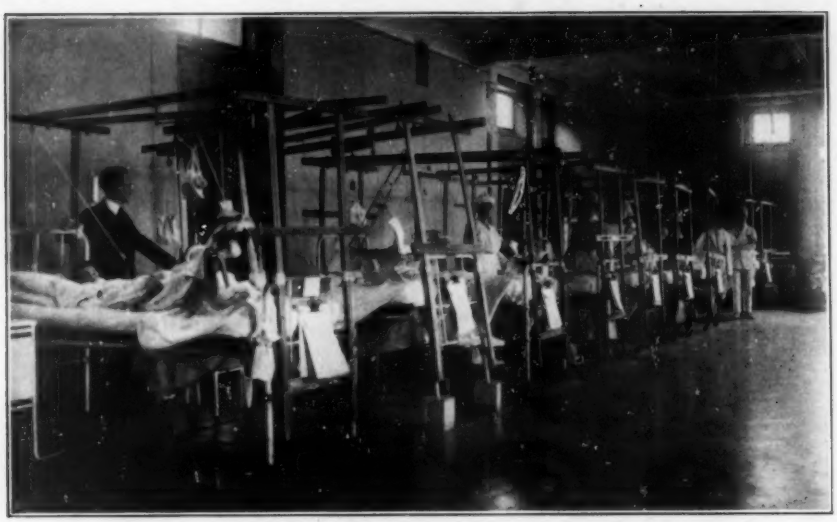

Fig. 26.—The fracture ward, showing the number of cases on a general surgical service of ninety beds.

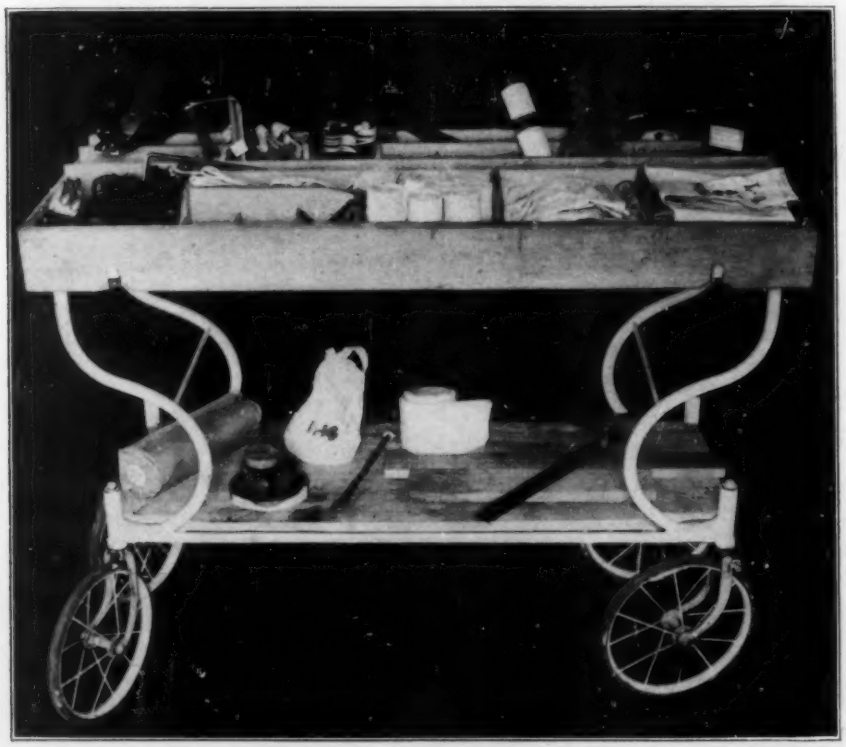

Fig. 27.—The fracture truck assembled by Dr. Bulkley. This carries everything needed in applying suspension traction and is a most essential unit in the equipment.

of 8 feet and landing on the foot with leg extended. The treatment was by means of traction on the Steinmann pin through the tibial head, and suspension at first with the leg extended. After five weeks the movable leg attachment was utilized, traction removed, and active movement at the knee instituted. The result is given in Figure 25, when the function of the knee was excellent and the patient could walk without pain or limping. Flexion beyond a right angle was present.

No other similar case has come under treatment, but the outcome here indicates that the suspension traction treatment can be used to advantage.

The traction suspension treatment has also been found efficient in badly comminuted or long spiral fractures of the tibia and fibula near the ankle joint. The tongs may be placed either in the malleoli or the os calcis. Figure 23 shows one case of this sort treated with an excellent result. Our experience has led to the conviction that this method of treatment is deserving of careful study on the part of those treating fractures. In a hospital where fractures are treated in any number, it should constitute the standard treatment. Its possibilities, I believe, are greater than the results here shown. It is not, however, a method easy of use, and only by rather long intensive study may one perfect himself in the technic.

The study on the Bellevue service has been carried on by the entire staff. I desire particularly to express my appreciation to my former associate surgeons Dr. Kenneth Bulkley and Dr. James Worcester, who successively have had charge of the fracture work, and to the resident surgeon, Dr. Russell Patterson, who has taken most of the roentgenograms and given valuable aid in the preparation of this communication.

THE RELATION OF SURGICAL TECHNIC TO GASTROJEJUNAL ULCER*

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OMAHA

Previous to the performance of gastro-enterostomy for ulcer, we find the lesion practically always in the duodenum, pylorus, and lesser curvature. Following the operation, if a new ulcer occurs, it is practically always in the region of operative procedure, that is, in the jejunum, stomach, or on the rim of the anastomosis; occasionally a new ulcer occurs on an old suture line such as is found in the resected stomach. The location and the time of occurrence of the ulcers before and after gastro-enterostomies are so dissimilar that a different etiology is most strongly suggested. Reports of new peptic ulcers occurring after this operation must be carefully analyzed as such ulcers are generally the old ulcers reactivated, which had never healed, or are new ulcers in the region of previous surgical procedure. Can the latter be termed true peptic ulcers?

Gastrojejunal is the adjective used to describe the ulcer which occurs in the region of the anastomosis after gastro-enterostomy. The terminology, however, is not appropriate as it does not properly describe the regional occurrence. We should expect a gastrojejunal ulcer to involve always the stomach and jejunum. These postoperative ulcers are herewith listed in the order of their frequency: (1) in the jejunum close to the anastomosis; (2) along the edge of the anastomosis; (3) in the stomach close to the anastomosis, and (4) we might add another region, which is along the line of closure of a resected stomach. Regardless of whether or not they all have the same etiology and granting that they are all postoperative, the term gastrojejunal does not describe correctly such ulcers, nor does it designate their location since there are four distinct areas of occurrence.

One noteworthy feature of the so-called gastrojejunal ulcers is that they are always found in proximity to the region of operative procedure, that is, along the previous suture line or about where a clamp had been placed. The more or less constant regional occurrence suggests more or less constant etiologic factors, and this singular regularity indicates that these ulcers seek a certain soil. This characteristic is a most

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* From the Department of Experimental Surgery, Nebraska University College of Medicine, Omaha.

* Read before the first annual meeting in Nebraska of the American College of Surgeons, Omaha, March 3, 1921.

important point since we know that this soil did not exist before the operation. There probably is no one etiologic factor, which may also be true of peptic, duodenal and gastric ulcer, but it seems quite logical to assume that gastrojejunal ulcer must be due primarily to the change in chemistry, to the surgical technic, or to both. Infections from a distant focus or a general constitutional derangement can hardly be considered as primary factors.

The passage of gastric contents directly into the jejunum is regarded by many as the direct or primary etiologic factor for all types of gastrojejunal ulcer, but this can be considered only for those ulcers occurring on the jejunal side of the stoma. The change in chemistry is not so marked as has been taught. The rapid propulsion of boli of food from

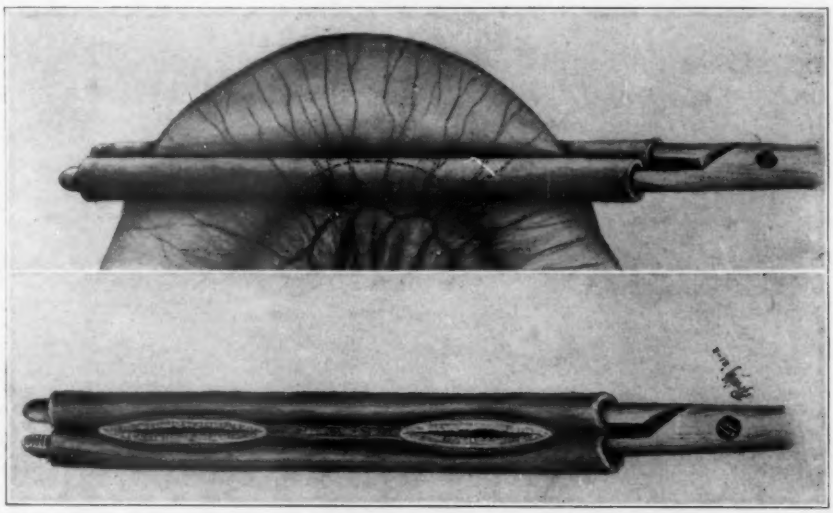

Fig. 1.—Lateral and cross-sectional view of jejunum in clamp. The inclusion of the mesentery may be noted, necessitating marked pressure on the jejunal walls to produce hemostasis.

the stomach, through the duodenum and upper jejunum, too fast to become thoroughly alkalinized, suggests that acid as well as alkaline products pass through this segment and that it is not entirely alkaline in reaction. I have repeatedly allowed the tip of a duodenal tube to pass to the distal duodenum, and, after feeding a soft mixed meal, have obtained contents of marked acidity. Therefore in gastro-enterostomy a segment accustomed to marked acidity is joined to one accustomed to both alkalinity and acidity.

Perhaps no one factor can be assigned as the cause of the so-called gastrojejunal ulcer, but the terminology is nevertheless in need of revision in order better to describe the regional and relational occurrence

of one of the most serious complications of a gastro-enterostomy. These ulcers occur probably in not more than 5 per cent. of patients operated on, but as the operation is so frequently performed, their actual occurrence is of sufficient moment to open a new department of surgery in the upper abdomen. These ulcers present difficult surgical problems, which require no little resourcefulness, and an exceptionally good technic for their solution.

ULCERS OCCURRING IN THE JEJUNUM

The majority of these postoperative, gastrojejunal ulcers occur in the jejunum close to the anastomosis where the clamp had previously

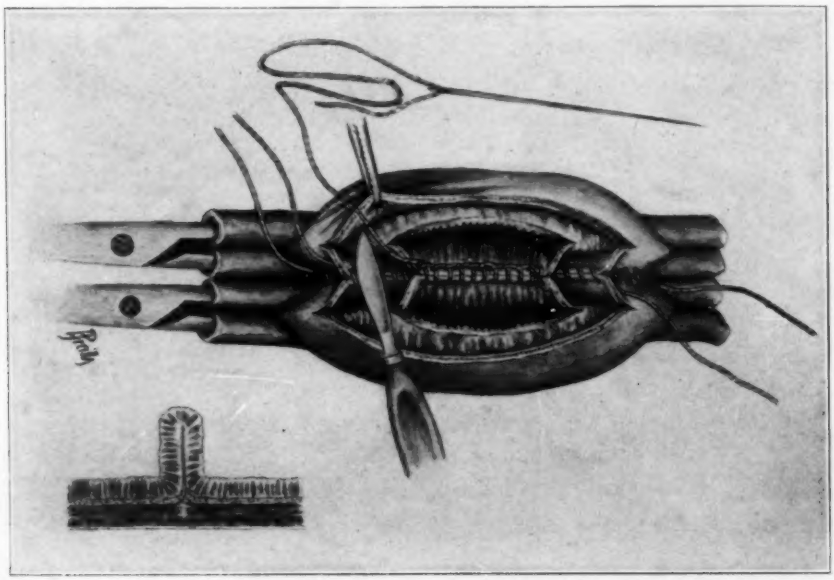

Fig. 2.—Gastro-enterostomy performed by author's technic. The separation of the mucosa from the muscularis for about one-fourth inch and the method of suturing may be noted. The mucosa is penetrated by the suture only along the edge.

been placed and in the area where so frequently an interrupted silk or linen reinforcing stitch had been placed. It is this ulcer which is attributed by many to be the result of contact of the gastric contents with a mucosa unused to any but a secretion with an alkaline reaction. The high acidity, however, rapidly decreases following this operation. The rapidity with which this acidity decreases is enhanced considerably by the alkalis which are so frequently administered during the post-operative treatment. Furthermore, the mucosa of the duodenum and upper jejunum resists acrid chemical secretions, and, as previously

stated, is not unused to acid contents. Since physiologic chemistry and biologic stamina are variables, a certain proportion of individuals are no doubt distressed and even injured by gastric secretions in the jejunum, but it seems hardly logical to state that all jejunal ulcers are due entirely to acid gastric contents.

It is significant that most ulcers in the jejunum occur close to or in the region where the clamp was placed. A portion of the jejunal mesentery is generally caught in the clamp (Fig. 1), which fact illustrates the amount of pressure necessary on the thick jejunal walls to compress sufficiently for hemostasis the much thinner jejunal

Fig. 3 (Dog 1).—Amputated end of stomach following Billroth II operation. The scar bound mucosa may be noted.

mesentery. How frequently during the performance of a gastro-enterostomy do we have to tighten the blades holding the jejunum because of the bleeding after it is opened, the pressure then becoming considerably greater than on the stomach. The trauma of the clamps, which is always severe, must, not infrequently, produce more or less injury to the jejunal mucosa and submucosa, sufficient injury, at any rate, to result in an immediate sloughing of an area of mucosa, or in deposits of scar tissue in it and the submucosa—a pre-ulcer condition or a factor predisposing to ulcer formation. The area of injury from the clamp, the point where frequently the reinforcing interrupted non-

absorbable suture is placed, the portion of the intestine where the gastric secretions first strike the jejunal mucosa, and the region where most jejunal ulcers occur form a significant combination of coincidences.

ULCERS ALONG THE EDGE OF THE ANASTOMOSIS

Postmortems a few weeks or more after a gastro-enterostomy reveal very plainly, along the suture lines of the anastomosis, mucosa bound down by a scar which is in marked contrast to the healthy, adjacent mucosa. Because of its rugous formation a normal mucosa in the stomach and jejunum enjoys marked excursion over the layers beneath it; it also possesses a very free blood supply. Few attempts have ever been made to simulate nature in operative technic as is

Fig 4 (Dog 2).—Gastro-enterostomy opening looking into the jejunum. The presence of scar bound mucosa along the edge of anastomosis may be noted. The scar binding effect of the suture passing through all three coats of the stomach and bowel wall is plainly seen.

demonstrated by the mucosa bound down by a scar following surgical procedures, which might well be considered as a predisposing as well as a most important factor in the etiology of ulcers occurring on the postoperative suture line.

The vast majority of these suture line ulcers occur along the edge of the anastomosis; the remaining ones occur along the old line of suture in the resected stomach. As previously stated, they follow the absorbable as frequently as the nonabsorbable suture, but I am unaware of a nonabsorbable suture reported as partially retained in the end

of a resected stomach, which may be due to a better union here than between gastric and jejunal tissue. Gastric secretions may be of greater potency in the latter region (the anastomosis) because of the slightly more sensitive jejúnal mucosa. There is no dispute about the non-absorbable suture's being a direct factor in a certain percentage, but for those ulcers following the use of catgut it is very likely that the etiologic factor is the scar tissue which is susceptible to the corrosive action of gastric juice.

Of all regions requiring a healthy mucosa, it seems most necessary in the lining of a gastro-enterostomy. Contact with hot and cold foods, the acrid chemical secretions from the stomach and duodenum, together with the trauma from traction and food friction, strongly indicate that we must leave this area better prepared to resist injury than we have in the past.

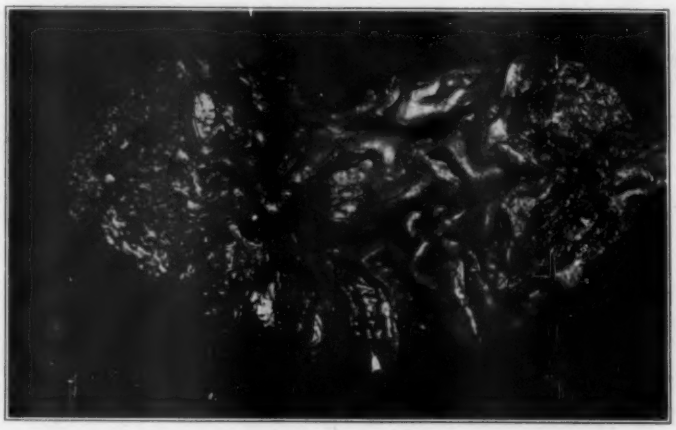

Fig. 5 (Dog 3).—Amputated end of stomach following resection of the pylorus. Absence of scar bound mucosa as seen in Figure 3 may be noted.

ULCERS OCCURRING IN THE STOMACH

The vast majority of ulcers occurring in the stomach following a gastro-enterostomy are found close to the line of anastomosis about where the clamp was applied and also corresponding to one of the areas where a deep interrupted, reinforcing Lembert suture of silk or linen was placed. This regional occurrence is similar to that of the jejunal ulcer, further indicating the probable significance of the clamp. The grip of the clamp is necessarily severe in order to hold the stomach in place, subjecting the mucosa to such trauma that it may even be divided as reported by Coffey. This trauma naturally results in Nature's response with an immediate slough or a scar tissue deposit in the submucosa—a pre-ulcer condition.

The occasional ulcers occurring elsewhere in the stomach following a gastro-enterostomy are generally reported as being of the true peptic type. From my study of such reports, it is quite evident that not all of these ulcers are of this variety and that they will generally be found along the line of the previous suture. Since these ulcers have never existed before, they cannot be classed as recurring. With these ulcers in the stomach, the acidity is a normal environment, and even that is greatly reduced after the operation, thereby further signifying that the chemical condition is merely a contributing or secondary factor.

Fig 6 (Dog 4).—Gastro-enterostomy opening looking into jejunum. The absence of scar bound mucosa may be noted.

COMMENT

It is evident that the so-called gastrojejunal or postoperative ulcer is found in the region of previous operative procedure, and since we know Nature's constant response is always scar tissue, we must give this reaction primary consideration relative to the etiology of this ulcer, submitting it as probably the most important predisposing factor. This seems fairly logical as we are beginning to conceive that no ulcer, peptic or "postoperative," has one direct causative factor and that the greatest number occur in certain areas which require a certain soil, namely, a localized anemia.

The use of the absorbable suture has marked a distinct advance in gastric surgery, but the technic is still in need of considerable

refinement. The trauma from our improperly constructed clamps and our methods of suturing has been greatly underestimated; and we have not made sufficient effort to leave the field of operation as we found it. The mucosa is the most important layer and must be kept in mind as occurring normally in a superabundant and rugous formation in the jejunum and more so in the stomach. Every bit of it should be preserved during the operation, and it should never be penetrated by a suture excepting closely along the edge. The use of mass sutures which pass entirely through all three coats has a most pernicious influence on the mucosa, first, by strangulation, and later, by immobilizing it with scar tissue. This method also shuts off the necessarily

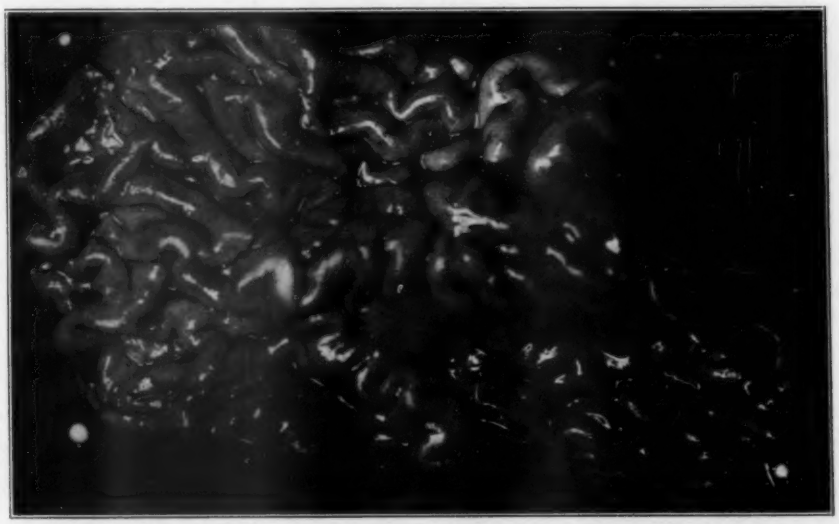

Fig. 7 (Dog 5).—Transverse incision made through the anterior wall of the stomach. The absence of scar bound mucosa may be noted.

abundant blood supply of the mucosa. The avoidance of hard knots of numerous ligatures seems essential as they must remain as nidi of infections causing future trouble. It seems reasonable to state that if any mucosa remains in superabundance, enjoying ample excursion and a normal blood supply, no ulceration can result in any portion of the gastro-intestinal tract. Following the ordinary technic, an immobilized, thinned, and scar-bound mucosa is the usual picture seen a few weeks, or later, along the line of previous suturing. Any postmortem examination will demonstrate this. Such mucosa, together with the trauma from clamps and interrupted reinforcing sutures, signifies that other factors must be seriously considered besides the acid gastric contents as the etiologic factor in postoperative ulcer production.

TECHNIC

The results of the technic to be described simulate more closely the natural conditions than those following any other technic of which I am aware. It is not entirely original, as the mucosa has been sutured separately by others ever since the operation of anastomosis has been practiced, but there are a few features I have not found emphasized elsewhere.

The mucosa is dissected from the muscularis for about one-fourth inch (Fig. 2), not only to obtain a superabundance but also to have the edge of the combined outer coats free enough to be easily sutured separately. This dissection does away with any possibility of the second row of sutures ever penetrating the mucosa, preventing almost entirely the usual sloughing of the mucosa by the through and through suture and also its immobilization by scar tissue infiltration. The mucosa is also sutured separately and only along the very edge in order to have a rugous formation over the rim of the anastomosis, simulating as much as possible the normal lining of the stomach and jejunum. The second row of sutures takes in only the muscularis and serosa, having been dissected free from the mucosa. The outer or third row

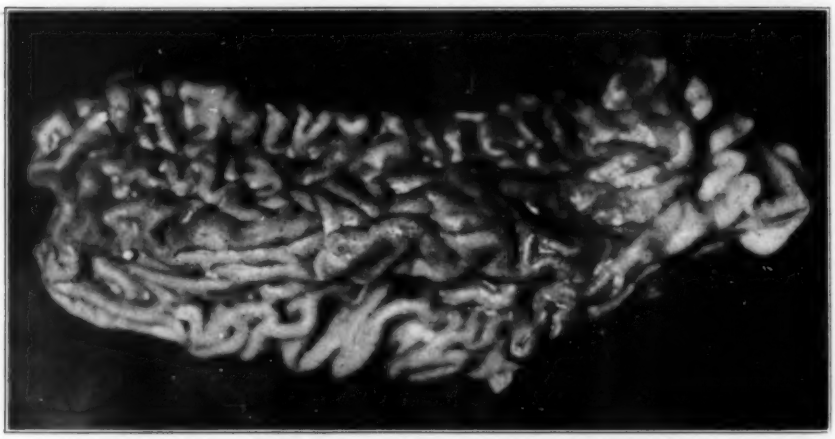

Fig 8 (Dog 6).—Longitudinal incision in anterior wall of stomach. The suture line which is not scar bound and which is acceptable as a satisfactory union may be noted.

of sutures is the usual seromuscular, to relieve tension and assure that there is no leakage.

In this technic, the mucosa is sutured only once and then close to the edge, and every effort is made to prevent passing any portion of the two outer layers of sutures through it, which precaution leaves it as free as possible and with very little interference with its blood supply. No hemorrhage can possibly result as the mucosa is united with a lock stitch, and the two outer rows are plain running sutures, all perfect hemostatics if applied properly. Catgut only should be used in the two outer rows. Any type of suture, absorbable or nonabsorbable, may be used on the mucosa since it rapidly sloughs into the lumen.[1]

1. Lewis, Dean: Personal communication.

In all resections of the stomach the mucosa should be as carefully preserved, which measure necessitates, whenever possible, the use of noncrushing clamps.

PROTOCOLS

EXPERIMENT 1.—Dog 1 was operated on Oct. 2, 1920, and necropsy was performed Dec. 3, 1920. The pylorus was resected and the ends of the stomach and duodenum were closed with two rows of sutures. The inner row of 0 chromic gut was passed through all the coats of the viscus, no attempt being made to suture the mucosa separately. The outer rows of fine silk were passed through the serosa and muscularis.

Figure 3 illustrates the closed end of the stomach after a few hours' immersion in a 10 per cent. dilution of liquor formaldehydi. Scar bound mucosa representing suture line may be noted.

EXPERIMENT 2.—Dog 2 was operated on Oct. 2, 1920, and necropsy was performed Dec. 3, 1920. An anterior gastro-enterostomy was performed, with two rows of sutures: the inner row of 0 chromic catgut passed through all

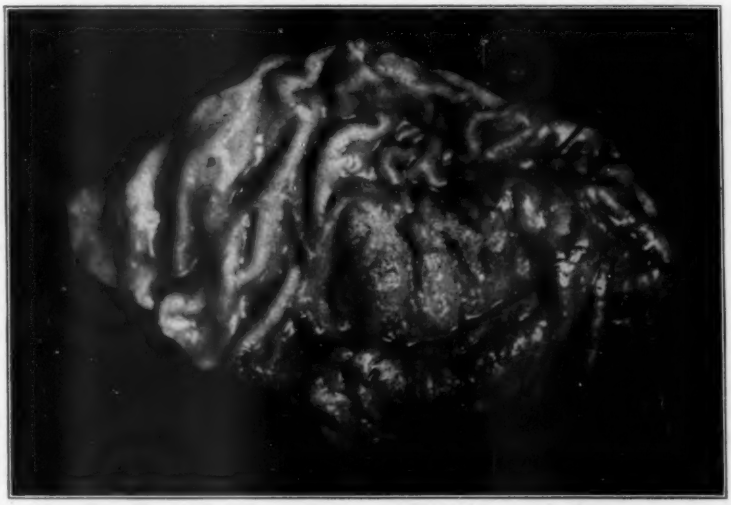

Fig. 9 (Dog 7).—Author's technic used in the upper half of the gastro-enterostomy opening, with absence of scar tissue. The usual through and through suture technic is used in the lower half, showing scar bound mucosa.

the coats of the viscus, no attempt being made to suture the mucosa separately; the outer row of 0 chromic gut, passing through the serosa and muscularis.

Figure 4 illustrates the gastro-enterostomy stoma after a few hours' immersion in 10 per cent. picric acid solution, which unfortunately removed the rugous formation in the mucosa surrounding the scar bound edge of the new opening, doing away with the contrast. The mucosa, however, plainly appears as thinned and scar bound.

EXPERIMENT 3.—Dog 3 was operated on Oct. 9, 1920, and necropsy was performed Dec. 3, 1920. The pylorus was resected with the ends of the stomach and duodenum closed with three layers of 0 chromic gut sutures. The mucosa was dissected free from the muscularis for about one-fourth inch and

sutured closely along the edge. The muscularis and serosa were likewise sutured, carefully avoiding the mucosa, and the third row of sutures was passed as the usual seromuscular, inverting the second row.

Figure 5 illustrates the closed end of the stomach after about one hour's immersion in a 10 per cent. dilution of liquor formaldehydi. The mucosa, which appears almost as free and thick as the surrounding tissue, may be noted and contrasted with Figure 1.

EXPERIMENT 4.—Dog 4 was operated on Nov. 20, 1920, and necropsy was performed Dec. 21, 1920. An anterior gastro-enterostomy, with three rows of 0 chromic gut sutures, was performed. The mucosa was dissected free from the muscularis for about one-fourth inch and sutured carefully along the edge. The muscularis and serosa were likewise sutured, carefully avoiding the mucosa, and the third row was passed as the usual seromuscular, inverting the second.

Figure 6 illustrates gastro-enterostomy stoma after a few hours' immersion in a 10 per cent. dilution of liquor formaldehydi. The free and abundant mucosa may be noted covering the suture line and appearing quite normal.

EXPERIMENT 5.—Dog 5 was operated on Nov. 20, 1920, and necropsy was performed Dec. 20, 1920. A transverse incision was made in the anterior stomach wall and closed with three layers of 0 chromic gut. The mucosa was dissected free from the muscularis for about one-fourth inch and sutured carefully only along the edge. The second row of sutures took in the muscularis as well as the serosa, carefully avoiding the mucosa, and the third row was the usual inverting stitch.

Figure 7 illustrates the inner aspect of the stomach and suture line, which is hardly discernible. The mucosa appears quite normal: abundant, mobile, and of normal thickness.

EXPERIMENT 6.—Dog 6 was operated on Nov. 20, 1920, and necropsy was performed Dec. 21, 1920. A longitudinal incision was made in the anterior wall of the stomach, and closed with three layers of 0 chromic gut. The mucosa was dissected free from the muscularis for about one-fourth inch and sutured carefully only along the edge. The second row of sutures took in the muscularis as well as the serosa, carefully avoiding the mucosa, and the third row consisted of the usual inverting stitch.

Figure 8 illustrates the inner aspect of the stomach and suture line, which is more discernible than in Figure 9, but acceptable as a union approaching the normal.

CONCLUSIONS

1. The adjective gastrojejunal improperly describes the type of ulcers following gastro-enterostomies since the term does not designate their regional and relational occurrence. Since these ulcers are a post-operative morbidity, the technic of surgical procedure should be more carefully studied.

2. The mucosa is the most important layer relative to chronic ulcer in any portion of the gastro-intestinal tract. During operations, it should be preserved to the utmost, simulating Nature as much as possible in the following respects: superabundance, marked mobility, and ample blood supply. This method is suggested by the fact that

preoperative and postoperative ulcers generally occur in the area where vascularity is comparatively less and where the mucosa is less abundant.

3. The mucosa should be sutured separately and only along the very edge; no other suture should ever penetrate this layer in order to prevent scar tissue infiltration and immobilization—the pre-ulcer condition. Whenever possible, the mucosa should be dissected free from the muscularis, which measure also allows the outer coats to be sutured separately with very little chance of including the mucosa.

4. The main object of this report is to emphasize that: (1) the so-called gastrojejunal ulcer is very likely the direct result of operative procedures; (2) every effort should be made to simulate Nature as much as possible by leaving the mucosa superabundant, with a free blood supply; and (3) in the technic of gastro-intestinal surgery, the mucosa should always be sutured separately close to the edge. No sutures should be passed through all three coats at one time since such a procedure strangulates the mucosa, later immobilizing it with scar tissue, which in addition shuts off the blood supply.

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A METHOD OF DETERMINING THE EARLY REGENERATION OF NERVE FIBERS AT OPERATION*

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In an article which is to appear shortly in the *Archives of Neurology,* an instrument, called a "chronomyometer," for testing muscles whose nerve supply has been interfered with, is to be described. Evidence will be presented to show that when a nerve injury is complete and the patient is seen months after injury nonoperative treatment and careful electrical examinations are the procedures of choice, within certain limits. If, however, the nerve injury is complete and the patient is seen early, the method here described would seem to make early exploration of the nerve the method of choice.

When one explores an injured nerve and finds the nerve intact but thinned out or greatly thickened at some point, the question arises: Are axis cylinders passing through this area? If they are regenerating, the nerve should not be cut and resutured, but if they are not regenerating and sufficient time has elapsed to allow them to have grown through the suspected area, a secondary suture should be made. The next question which presents itself is: How are we to ascertain whether regeneration is occurring? At present, to my knowledge, the only method used is to stimulate the nerve trunk central to the lesion and note whether there follows any contraction of the muscles innervated by that nerve. Obviously, if regeneration were occurring but had reached, say, only half of the distance from the lesion to the muscles, no contraction would follow and one would proceed with the secondary suture. This would be doing the patient harm not only because it would delay regeneration many months but also because regeneration following a secondary suture is said to be not so promising as when the nerve trunk is intact. The delay in regeneration and the harm done the patient will vary with the distance between the suture line and muscles innervated by the nerve tested and the distance regenerating fibers had passed the point of injury. A case of brachial plexus injury illustrates this difficulty very well.

CASE 1. (Surg. No. B. H. 8213).—The patient had complete paralysis and anesthesia of the entire left arm two months after injury. The brachial plexus was explored and the three primary cords showed an area about 1 cm. in length

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which was about two thirds of the diameter of the remainder of the nerve trunk. This area did not appear to be normal nerve tissue, and stimulation of the nerve trunk failed to elicit any contractions of muscles. The thinned area was resected from one of the cords and a secondary suture inserted. Microscopic examination of the resected tissue revealed many axis cylinders, and one year later the patient showed marked regeneration of nerves both in those having their origin in the primary cord resected and from the primary cords that had not been resected, showing that the resection was unnecessary.

It is a well known fact that when a peripheral nerve is stimulated, by the application of cold to the skin in human beings or by direct stimulation of the trunk in animals, there is a reflex stimulation of the respiration, blood pressure and reflex contraction of muscles innervated by nerves other than the one stimulated. These phenomena are so well established and constant that it was felt that they might be used as an index of regeneration when the nerve trunk was exposed at operation.

EXPERIMENTS TO DETERMINE INDEX OF REGENERATION

With this in mind, eighteen experiments were performed on dogs and twenty-five tests were carried out on them. Different types of operation which had been performed for a study of methods of repair of peripheral nerve lesions are included in this series. The types of operation performed were: (1) end-to-end suture; (2) lateral anastomosis of the injured nerve into a slit in a normal nerve; (3) lateral anastomosis of the injured nerve to a flap cut in a normal nerve, and, (4) autotransplant of half of the central end of the injured nerve.

In each case the nerve was cut, repaired, and at varying intervals after operation, the test was applied. The test consisted in stimulating the normal central portion of the nerve with a faradic current which was just strong enough (threshold current) to stimulate definitely the respiratory center. This strength of current was then applied at varying distances distally from the suture line, and the central and peripheral effects recorded graphically or merely by inspection. The blood pressure was recorded in some cases. The physiologic results were checked up by histologic examination of the nerves which were stained by the pyridin-silver method of Ranson.[1] The condition of the reflexes, especially the corneal, were noted because the test is a reflex phenomenon, and the reflexes are depressed or paralyzed by deep anesthesia. Thus, the degree of anesthesia must be controlled so that the reflexes are very active.

1. Ranson, S. W.: Degeneration and Regeneration of Nerve Fibers, J. Comp. Neurol. **22**:487, 1912.

TABLE 1.—Testing Nerves at Operation for Presence of Axis Cylinders: Corneal Reflexes Very Active Unless Otherwise Stated

Exp. No.	Days After Repair	Distance of Axis Cylinders Below Suture Line Histologically	Muscle Contractions on Stimulation of Nerve Peripheral to Suture	Respiration on Stimulation of Nerve Peripheral to Suture	Blood Pressure on Stimulation of Nerve Peripheral to Suture	Remarks
1	234	To all muscles	+	Increase rate and depth	Increased	Response as with normal
2	169	To all muscles	+	Increase rate and depth	Increased	Response as with normal (good record of this)
3	157	To all muscles	+	No change	No change	Anesthesia deep
4	161	To all muscles	+	Increase in depth	Slight increase	Only 2 trials made with very weak current but response same as with this animal's normal nerves
5	152	To all muscles	+	Increase rate and depth	.....	On cutting tibial nerve central and waiting 18 days, muscular contraction weak and stimulation of respiration weak on stimulation of tibial peripheral
6	106	To all muscles	+	Increase rate and depth		
7	150	To all muscles	+	Increase rate and depth	Increased	Corneal reflex present (good record)
			+	Very slight increase depth	Not changed	Corneal reflex absent; stimulation was 3 cm. distal to suture line and response same with unrepaired nerves (good record)
8	150	To all muscles	+	Increase rate and depth	Slight increase	As strength of current increased so did the response; reaction same central to both suture lines as peripheral (good record)
9	120	To all muscles	+	Increase depth with slight slowing	Slight increase	Reaction same central as peripheral to suture lines (fair record only)
10	60	10-12 cm.	—	Increase rate and depth	Increased	Reaction same central as peripheral to suture lines; response better and stronger current used (good record)
11	60	10-14 cm.	—	Rate increase 12 per min. and decrease slight in depth with weak current; with strong current rate decreased 8 and increased depth	Rise of 5-10 mm.	Corneal reflex present (fair record)
				—	—	Corneal reflex absent (fair record)
12	3	0	±	—	—	
13	3	0	—	—	—	Usual change of blood pressure and respiration on stimulating 1 cm. central to sutures
14	90	To all muscles	+	48 per min. before and 60 per min. during stimulation		
15	90	To all muscles	+	Rate decreased 27 to 22, depth markedly increased		
16	90	To all muscles	+	Rate increased 36 to 48 per min		

TABLE 2. (EXP. 17).—LEFT SCIATIC CUT AT LEVEL OF MIDTHIGH AND END-TO-END SUTURE DONE, APRIL 14, 1921: CORNEAL REFLEXES VERY ACTIVE AND ANESTHESIA LIGHT DURING TESTS.

Date	Distance of Electrodes Distal to Suture Line	Stimulation of Respiration	Reflex Contraction of Muscles	Response of Muscles Innervated by Injured Nerve	Remarks
4/14/21	½ cm.	Slight	Definite	Marked	No spread of current to central or peripheral ends when electrodes were placed 1 cm. or more from suture line
4/21/21	3 mm. or more	None	None	None	
4/28/21	3 mm. or more	None	None	None	
5/12/21	6 mm. or more	None	None	None	
5/27/21	35 mm. or more	None	None	None	Level where central effect disappeared sharply defined; histologic examination of nerve showed large number of axones 35 mm. distal to suture line and a few 45 mm. distal to suture line
	Less than 35 mm.	Definite	Definite	None	

Summary: A threshold current applied 1 cm. or more distal to the suture line does not spread to the central end at any time after complete injury to the nerve. The presence of regenerating axones could not be detected with certainty at the end of the fourth week but could be positively determined at the end of the sixth week (not tested at the end of the fifth week). When the physiologic response was present the axis cylinders were 10 mm. distal to the level at which the central effect could no longer be elicited.

TABLE 3 (EXP. 18).—LEFT SCIATIC CUT AT LEVEL OF MIDTHIGH AND END-TO-END SUTURE DONE APRIL 14, 1921: CORNEAL REFLEXES VERY ACTIVE AND DEPTH OF ANESTHESIA VERY LIGHT

Date	Distance of Electrodes Distal to Suture Line	Stimulation of Respiration	Reflex Contraction of Muscles	Response of Muscles Innervated by Injured Nerve	Remarks
4/14/21	½ cm.	Slight	Definite	Marked	No spread of current to central or peripheral ends when electrodes were placed 1 cm. or more from suture line
4/21/21	3 mm. or more	None	None	None	
5/ 5/21	5-6 mm. or more	None	None	None	
5/20/21	20 mm. or more	None	None	None	Level where central effect disappeared sharply defined; histologic examination of nerve showed large number of axones 15 mm. distal to suture line and a few 25 mm. distal to suture line
	Less than 20 mm.	Definite	Definite	None	

Summary: Same as in Experiment 17 except that regenerating fibers could be detected positively at the end of the fifth week. When the physiologic response was present the axones were from 5 to 10 mm. distal to level at which the central effect could not be elicited.

CASE 2 (Surg. No. B. H., 10589).—The patient had a brachial plexus injury of four years' standing. There was sensation to the midarm, very little voluntary movement in the muscles of the arm, but the chronomyometer test of the muscles of the arm showed a short nerve-muscle complex while the muscles in the forearm and hand did not show even the muscle complex. At operation for midarm amputation, the nervus cutaneus brachii medialis and nervus medius were stimulated with a faradic current at the level of the middle of the arm. No change in the respiration or muscular contractions was noted on stimulation of the nervus medius while stimulation of the nervus cutaneus brachii medialis

increased the rate of respiration from 18 to 38 per minute and the depth definitely. This change was so marked that it was seen by all present. Histologically, there were no axones in the nervus medius while there was a large number in the nervus cutaneus brachii medialis.

Summary.—Where there were no axones, no central effect was noted while a very definite central effect was noted when the normal nerve was stimulated.

COMMENT

A study of the tabulated results and protocols reveals these facts:

1—Stimulation of a peripheral nerve (normal or regenerating) has such a definite effect on the respiration in animals and human beings

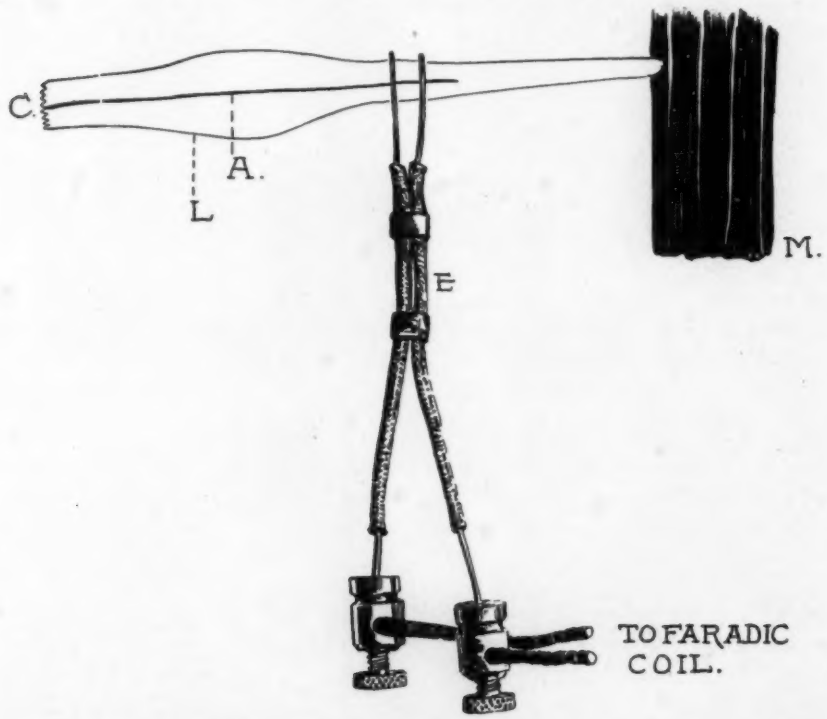

Diagram of method of reflexly stimulating the respiratory center when no contractions of the muscles are present: *A*, axis cylinder; *C*, central end of nerve; *E*, electrode applied to nerve below lesion *L*; *M*, muscle.

that it is easy to observe the effect, and thus a graphic record is unnecessary. The recording of the blood pressure changes is unnecessary.

2—Reflex contractions of muscles which receive their nerve supply from normal nerves or from branches of the nerve tested which leave the main trunk of the nerve central to the lesion are of definite value in determining the presence of regenerating fibers. This is very constant in its occurrence but is present only under the same conditions

as is the reflex stimulation of the respiration. The threshold of current necessary to cause reflex contractions is a little less than that necessary to affect the respiration.

3—Immediately after cutting a nerve and resuturing it, a threshold current spreads across the suture line, but after a week, there is no spread across the suture line when the electrodes are placed more than 3 mm. from the suture line. After five weeks, when regenerating fibers have passed the suture line from 2½ to 3 cm., there is a definite stimulation of the respiration and reflex contraction of muscles with a threshold current applied 2 cm. distal to the suture line. From this time on the reflex effect on respiration is always present and can be elicited at greater and greater distances distal to the suture line as regeneration progresses. Finally, when the regenerating axones reach the muscles, both their contractions and the central effect described above are present as in a normal nerve.

4—The strength of current used should not be stronger than that just necessary definitely to stimulate the respiration when applied to the normal portion of the central stump of the injured nerve (threshold current). The electrodes should be applied from 1½ to 2 cm. or more distal to the injured portion of the nerve in order to avoid any possibility of the current spreading to the normal nerve central to the lesion.

5—When the test is applied, the anesthesia should be light so that the corneal reflexes are very active, for the test depends on the reflex arcs being active. Deep anesthesia will paralyze the reflexes. The proper depth of anesthesia is reached when stimulation of the normal central portion of the injured nerve causes a reflex effect without too strong a current.

6—The test is of no service in a pure motor nerve as the facial, but is applicable to any sensory or mixed nerve.

7—Contractions of muscles innervated by the nerve tested when the nerve is stimulated peripheral to the suture line may be present up to three days following section of the nerve; but they then disappear until regenerating fibers reach the muscles months later.

SUMMARY

The results in Case 1 indicate that the test, as worked out on animals, is applicable to cases of peripheral nerve injury in man and should enable one to make a diagnosis weeks and months earlier than it has been possible to do up to the present, and thus in many cases should enable one to recognize early regeneration and avoid the hazards associated with a secondary suture by preventing one from placing a secondary suture in a nerve in which regeneration is already occurring.

It is of value, however, only after the fifth week following injury, when the nerve is explored and found to be intact. It should not be necessary to explore a case in which the paralysis is due to a physiologic block when the nerve-muscle complex can be demonstrated with the chronomyometer. On the other hand, if only the muscle complex is present five or more days after the injury, the nerve has degenerated and the nature of the injury to the nerve can only be determined by exploring it or by waiting many months to see whether regeneration will occur.

When a nerve injury is seen late the usual procedure has been to wait a reasonable time until there are evidences of regeneration. These may be detected earlier by means of the chronomyometer.

The method here described would seem to be particularly useful in early cases as the test was positive after five weeks in dogs. It is possible that this time interval may be somewhat longer in man.

The experience of Lewis[2] in a large series of cases has been that approximately 80 per cent. of nerve injuries recover spontaneously. This method merely involves exposing the injured nerve and would seem justified in many if not all cases of nerve injury since it would enable the surgeon to discover very much earlier the 20 per cent. of cases that need operation and save the patient much time.

In infected cases, of course, it could not be used until a clean field is assured.

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2. Lewis, Dean: Peripheral Nerve Surgery, S. Clinics, Chicago **3**:769 (Aug.) 1919.

INTESTINAL OBSTRUCTION *

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DETROIT

A number of theories in explanation of the fundamental pathologic changes induced by intestinal obstruction have been developed in the last ten or twelve years. These theories represent the work and conclusions of many investigators, and no account of the subject would be complete which did not accord them due recognition and consideration. They may be briefly and conveniently classified under three general heads.

1. The theory of splanchnic paralysis and circulatory shock which conceded a place of primary importance to the distention and consequent circulatory disturbance in the bowel and their effect on the sympathetic nervous system through the nerve endings in the wall of the intestine. This theory is now of mere historical interest as a result of recent advances in our knowledge of the condition.

2. McLean and Andries [1] and Hartwell, Hoguet and Beekman [2] arrived, each group independently of the other, at the conclusion that water loss from drainage of the body fluid into the intestinal lumen, above the obstruction, was the cause of the systemic symptoms and eventual death.

3. The latest, and at present most widely accepted, theory is that the symptoms are due to toxemia of duodenal origin. Dragstedt, Moorehead and Burcky [3] have found toxic bodies in the obstructed duodenum which they believe are the result of bacterial action on the duodenal proteins, both food remnants and tissues. Whipple [4] and his collaborators deny the influence of bacteria and have found powerful poisons of the proteose group in the intestinal lumen following experi-

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* From the Buhl Memorial Laboratory, Harper Hospital.

1. McLean, Angus, and Andries, R. C.: Ileus Considered Experimentally, J. A. M. A. **59**:1614 (Nov. 2) 1912.

2. Hartwell, J. A.; Hoguet, J. P., and Beekman, Fenwick: Experimental Study of Intestinal Obstruction, Arch. Int. Med. **13**:701 (May) 1914.

3. Dragstedt, L. R.; Moorehead, J. J., and Burcky, F. W.: Intestinal Obstruction, J. Exper. Med. **25**:421 (March) 1917.

4. Whipple, G. H.; Rodenbaugh, F. H., and Kilgore, A. R: Intestinal Obstruction, J. Exper. Med. **23**:123 (Jan.) 1916.

mental obstruction. These poisons after filtration and reinjection into a healthy animal cause vomiting, diarrhea, rapidity of the pulse, collapse and other symptoms resembling those of intestinal obstruction. They conclude that the poisons are formed during a perverted activity of the lining cells of the duodenal mucosa and cause the toxic symptoms after absorption. Dragstedt [5] and other workers have since reaffirmed their belief in the bacterial origin of these poisons.

Later observations have led to the discovery that frequently intestinal obstruction is accompanied by remarkable changes in the concentration of the nonprotein nitrogen of the blood. This is not of constant occurrence, and intestinal obstruction may and does frequently exist when no significant changes in blood nitrogen concentration are present. In other cases, extreme rises are found such as occur in no other condition, uremia excepted. A pseudo-uremia, if such it may be termed, is present. These rises are in general associated with patients presenting the most severe systemic manifestations: rapid, feeble pulse and the general appearance of shock. The fundamental cause of, and precise indications for treatment conveyed by, this pseudo-uremia are at present questions of some uncertainty. Vaughan and Morse [6] find this concentration, particularly if repeated observations be made at intervals of a few hours, of value in both diagnosis and prognosis. Stone [7] considers it the cause of the constitutional symptoms and probably of death in uncomplicated fatal cases. Whipple and Cooke [8] have, by injection of proteoses isolated from the obstructed intestine, produced increased urinary and fecal elimination of nitrogen lasting for several days after injection. They believe it probable that the increase of blood nitrogen bodies in clinical cases of intestinal obstruction results from absorption of, and augmented protein destruction by, toxic substances elaborated in the duodenal mucosa under the conditions accompanying the obstruction.

EXPERIMENTAL WORK

Experimental work was undertaken to determine the influence, if any, of the water balance of the body on the progress of the condition and on the concentration and excretion of nonprotein blood nitrogen. Studies were made on dogs. All major operative procedures were

5. Dragstedt, L. R.; Dragstedt, C. A.; McClintock, J. T., and Chase, C. S.: Intestinal Obstruction, J. Exper. Med. **30**:109 (Aug.) 1919.

6. Vaughan, J. W., and Morse, P. F.: Blood Nitrogen Estimations in Genito-Urinary and Abdominal Conditions, Arch. of Surg. **3**:405 (Sept.) 1921.

7. Stone, H. B.: Toxic Agents in Acute Intestinal Obstruction, Surg., Gynec. & Obst. **32**:415 (May) 1921.

8. Whipple, G. H., and Cooke, J. V.: Proteose Intoxication and Injury of Body Proteins, J. Exper. Med. **25**:461-479 (March) 1917.

carried out under ether anesthesia. All minor operative procedures were carried out under 1 per cent. procain anesthesia. All dogs under experimental observation were kept stupefied with chloral hydrate. All nitrogen estimations given are in milligrams of total noncoagulable nitrogen per hundred c.c. of blood or intestinal exudate, as the case may be, and were determined after the method of Folin.[9] No estimations of the various component fractions, as urea, creatinin and uric acid were made.

As an illustration of what may be expected in intestinal obstruction, blood nitrogen estimations made on a typical example, Dog 6, are given in Table 1.

TABLE 1.—Blood Nitrogen Estimations in Dog 6

No.	Time	Milligrams per 100 C.c.	No.	Time	Milligrams per 100 C.c.
1	Normal	30	4	72 hrs.	86
2	24 hrs.	55	5	96 hrs.	92
3	48 hrs.	85	6	120 hrs.	150

This animal was operated on and a midjejunal obstruction produced by silkworm gut ligature about the intestine. He was penned up, and food and water left within reach. Nonprotein blood nitrogen estimations were made at twenty-four-hour intervals, the first normal, the last just preceding death. Necropsy revealed the obstruction intact, no gangrene nor perforation of the intestine, no peritonitis, no pneumonia.

In Dogs 1, 2, 3, 4 and 7 studies were made on well hydrated dogs with a measured fluid intake and output. Chemical studies were carried out on the fluid which drained into the intestinal canal to determine whether the nonprotein nitrogen bodies and their precursors in the path of protein disintegration accompanied the body fluids as they left the circulation and passed into the intestine. In all dogs, obstruction was produced by silkworm gut ligature about the intestine at the site designated. All fluid intake was given by saline hypodermoclysis to avoid the uncertainty accompanying the administration of water by mouth, much of which is immediately vomited or lies in the distended intestine and is never absorbed to become a part of the body fluid proper. The amounts given every twenty-four hours were roughly equal on a basis of comparative weights to a fluid intake of from 4,000 to 5,000 c.c. daily for a man weighing 150 pounds. This is greatly in excess of ordinary requirements without at the same time being more than a healthy circulation can absorb and distribute. Urinary output was collected by a retention catheter and the amount recorded every

9. Folin, O., and Wu, H.: A System of Blood Analysis, J. Biol. Chem. **38**:81 (May) 1919.

twenty-four hours, but no chemical studies were carried out on the urine. Intestinal drainage was collected in a bottle through a gastrostomy tube from the stomach, to which organ the fluid was carried from the site of excretion in the intestine by reverse peristalsis. All dogs were apparently in good health at the time of operation. The intestines

TABLE 2.—Results Obtained with Dog 1 (Male)*

Date	Time	A C. c.	B C. c.	C C. c.	D Mg.	E Mg.	F Mg.
4/3/21	12 n.	450	...	...	22	...	...
	4 p. m.	150	...	...	...	...	...
	8 p. m.	300	...	...	...	...	...
4/4	8 a. m.	450	...	...	...	...	...
	12 n.	...	190	80	22.8	92	73.6
	4 p.m.	450	...	...	...	...	...
4/5	8 a. m.	150	...	...	...	...	...
	12 n.	450	65	350	40	23	80.5
	4 p. m.	300	...	...	...	...	...
4/6	8 a. m.	450	...	...	...	...	...
	12 n.	...	25	77	25	240	184.8
	4 p. m.	Died					

*Operation was performed at 11 a. m., April 3, 1921; weight, 11,460 gm; ileocecal obstruction.

*Necropsy revealed: Intussuception for 10 inches above obstruction with commencing gangrene but no perforation. There was no pneumonia. There was upper abdominal peritonitis. The urinary bladder was empty.

* In Table 2 and in Tables 3, 4, 5 and 6, Column A represents the amount of saline given subcutaneously; B, urinary output; C, fluid output into the intestinal canal; D, concentration of total noncoagulable blood nitrogen in milligrams per hundred c.c.; E, the concentration of the same noncoagulable nitrogen bodies per hundred c.c. found in the intestinal fluid, and F, the absolute excretion of those bodies every twenty-four hours by the intestinal mucosa in milligrams.

TABLE 3.—Results Obtained with Dog 2 (Male)*

Date	Time	A C. c.	B C. c.	C C. c.	D Mg.	E Mg.	F Mg.
4/8	4 p. m.	600	...	...	19	...	...
4/9	8 a. m.	450	...	...	...	...	...
	12 n.	...	325	150	31	86	129
	4 p. m.	450	...	...	...	...	...
	7 p. m.	Died	10	240	...	240	576

*Operation was performed at 4 p. m., April 8, 1921; weight, 13,100 gm.; obstruction at end of jejunum.

* Necropsy revealed: Obstruction intact; upper abdominal peritonitis; no pneumonia, and an empty bladder.

were in a typical fasting state and contained small amounts of semifluid contents; not more than 10 or 15 c.c. in any case. Any fluid of intestinal origin beyond this amount must, of necessity, have come from the body reserve through the circulation. The intake figures recorded are quite accurate; the output figures represent a minimum rather than

the actual amounts, as they take no account of water vapor in the expired air, small amount of semifluid discharges from below the obstruction and small amounts of vomitus which escaped collection by the gastrostomy tube. Blood nitrogen estimations were made at twenty-four-hour intervals: the first normal, the last just prior to death.

A study of these records will reveal several facts of interest. In the first place, while changes occurred in the concentration of blood nitrogen, they were all within normal limits with one exception, 55 mg. per hundred c.c., the final record in Dog 3, which will be considered presently. The final figure 41.5 mg., for Dog 7, is so slightly above the upper limit of normal, 40 mg., as to be within the limit of error of the method of estimation employed. In both these dogs, the circulation was, in the last hours of life, so rapid and inefficient as to be unable to absorb and distribute the subcutaneous saline. This remained at the site of

TABLE 4.—RESULTS OBTAINED WITH DOG 3 (MALE)*

Date	Time	A C. c.	B C. c.	C C. c.	D Mg.	E Mg.	F Mg.
4/11	9 p. m.	500	...	...	24	...	..
4/12	8 a. m.	500	...	...	...	...	...
	12 n.	...	275	300	20	60	180
	4 p. m.	500	...	...	...	...	...
4/13	8 a. m.	500	...	...	...	...	...
	12 n.	...	425	430	35.5	46	197 8
	4 p. m.	500	...	...	...	...	...
4/14	8 a. m.	500	...	...	...	...	...
	12 n.	...	315	660	55	48	288
	4 p. m.	Died					

*Operation was performed at 9 p. m., April 11, 1921; upper jejunal obstruction; weight, 15,430 gm.

*Necropsy revealed: Obstruction intact; upper abdominal peritonitis; no pneumonia; urinary bladder empty.

administration in large edematous welts and, in consequence, whatever therapeutic value it possessed was not available beyond the localized area where it rested. It will be noted that Dogs 1, 2 and 3 suffered from peritonitis originating from leakage about the gastrostomy tube and complicating the obstruction. Dog 4 was killed with chloroform on suspicion that the obstruction had given way, which did not prove to be the case. Dog 7 had an extensive coexistent pneumonia. Vaughan has called attention to frequent rises in blood nitrogen during the last stages of a severe peritonitis. Myers [10] reports similar rises in unfavorable pneumonia cases. In neither of these conditions, however, does the rise attain the same magnitude as in intestinal obstruction. It seems probable that in both Dogs 3 and 7 the rise may be attributed to the

10. Myers, V. C.: Chemical Changes in the Blood in Disease, J. Lab. & Clin. Med. **5**:418 (April) 1920.

complication rather than the primary obstruction. When compared to Dog 6, the standard, only a very mild nitrogenous toxemia exists. It furthermore seems probable that death, in all cases, was due to the complication rather than the obstruction. Hartwell and Hoguet have demonstrated that, in the absence of complications, large administrations of subcutaneous saline serve to prolong the life of dogs with intestinal obstruction indefinitely. We believe also that in the absence of com-

TABLE 5.—Results Obtained with Dog 4 (Male)*

Date	Time	A C. c.	B C. c.	C C. c.	D Mg.	E Mg.	F Mg.
4/17	12 n.	500	...	...	28 6	...	...
4/18	8 a. m.	450	...	...	...	...	...
	12 n.	150	190	780	37.5	86	670.8
	4 p. m.	450	...	...	...	...	...
4/19	8 a. m.	450	...	...	...	...	...
	12 n.	...	32	490	29	43	210.7
	4 p. m.	450	...	...	...	...	...
4/20	8 a. m.	600	...	...	...	...	...
	12 n.	...	...	450	35.5	60	270
	4 p. m.	300	...	...	...	...	...
4/21	8 a. m.	450	...	...	...	...	...
	12 n.	...	...	300	28	92	186
	4 p. m.	450	...	...	...	...	...

*Operation was performed at 12 n., April 17, 1921; weight, 12,220 gm.; midjejunal obstruction.

*The dog was killed with chloroform at 4:30 p m. Necropsy revealed: No pneumonia, no peritonitis, obstruction intact, small amounts of urine passed after April 19, but not recorded because of breaking of catheter.

TABLE 6.—Results Obtained with Dog 7 (Male)*

Date	Time	A C. c.	B C. c.	C C. c.	D Mg.	E Mg	F Mg.
5/1	1 p. m.	450	...	...	23	...	...
	8 p. m.	300	...	...	...	...	...
5/2	8 a. m.	450	...	...	...	...	...
	12 n.	...	200	380	28	60	288
	4 p. m.	450	...	...	...	...	...
5/3	8 a. m.	450	...	...	...	...	...
	12 n.	...	175	445	27	44.5	198
	4 p. m.	450	...	...	...	...	...
5/4	8 a. m.	450	...	...	...	...	...
	12 n.	...	155	750	22 2	35.3	254
	4 p. m.	450	...	...	...	...	...
5/5	8 a. m.	450	...	...	...	...	...
	12 n.	...	195	720	30	44 5	320
	4 p. m.	450	...	...	...	...	...
5/6	8 a. m.	450	...	...	...	...	...
	12 n.	...	150	700	41.5	50	350
	4 p. m.	450	...	...	...	...	...

*Operation was performed at 1 p. m., May 1, 1921; weight, 9,625 gm.; middnodenal obstruction.

*The dog died at 4:30 p. m. Necropsy revealed: Obstruction intact; no peritonitis; pneumonia in right lower and middle lobes; urinary bladder empty.

plications, sufficient water serves to maintain the noncoagulable nitrogen of the blood within normal limits as it has in four of the five cases submitted. Further support for these statements will be offered shortly.

A second feature of interest is the outpouring of body fluids into the intestinal canal above the obstruction, amounting frequently to many times the urinary output every twenty-four hours. This is an occurrence which may be recognized clinically and is merely mentioned in passing. It may be seen that, in clinical cases, unless the fluid excreted into the intestine is replaced, a severe dehydration will rapidly occur; again that administration must be made by a route other than the mouth because ingested fluids are either vomited at once or lie in the distended intestine without being absorbed, since the intestinal mucosa is largely or entirely given over to excretion.

Thirdly, bodies of the nonprotein nitrogen group are found in this exudate; bodies responding to the same chemical tests which identify the waste nitrogen of the blood. The two are undoubtedly identical and pass from the blood stream into the intestine in solution with the fluid drainage. Reference to the foregoing tables will also reveal that at times the nonprotein nitrogen of the intestinal fluid exists in greater concentration than it does in the blood. The importance of this fact will be discussed later.

It becomes evident, after a study of Dogs 1, 2, 3, 4 and 7, that the rise of noncoagulable blood nitrogen in intestinal obstruction is profoundly influenced if a large supply of water is assured. If not entirely checked, it is at least minimized. As a result, it was decided to try the effect of severe water loss in the absence of intestinal obstruction. Accordingly, three dogs were penned up and permitted to die of thirst by merely withholding water. Blood nitrogen records are given in Table 7.

In the figures in Table 7 the first is normal, the succeeding readings were taken at twenty-four-hour intervals. The last in each series was taken just prior to death.

In this series we find the nonprotein nitrogen of the blood rising to concentrations quite similar to those of intestinal obstruction, Dog 6. Dog 11 was under observation during cool, moist weather and was almost totally inactive, making water loss very slow. Moreover, we cannot be certain that he did not obtain water on several occasions, and the presumption is that he did. The end-result was the same, however, and when thirst became severe the animal promptly developed a pseudo-uremia.

Since simple thirst when severe causes a rise of waste nitrogen in the blood to uremic heights, it was thought wise to try forced dehydra-

tion after the technic of Balcar, Sansum and Woodyatt [11] in their investigation of dehydration fever. These workers, by the intravenous injection of concentrated salt or glucose solutions, caused a urinary output which rapidly became greater than the fluid intake. Remarkable increases of temperature resulted after the dehydration had amounted to 30 or more cubic centimeters per kilogram of body weight. To their technic, we have added the estimation of nonprotein nitrogen in samples of blood taken at intervals between the start of the experiment and the death of the experimental animal.

TABLE 7.—Blood Nitrogen Estimations in Dogs Dying of Thirst

Dog 11 Milligrams per 100 c.c.	Dog 13 Milligrams per 100 c.c.	Dog 15 Milligrams per 100 c.c.
18	26	24
22.2	21.4	28.6
22.2	30	32.5
24	44.5	43
25	32	53.5
30	43	133
27.3	70	
28.6	120	
41.5		
34.8		
52		
43		
40		
30		
33.4		
36		
38.5		
60		
100		
200		

REPORT OF EXPERIMENTS

Experiment 1.—In Dog 8, male, weight, 11,340 gm., a solution containing 5 per cent. sodium chlorid and 0.7 per cent. lactic acid was injected intravenously at the rate of 150 c.c. per hour. Injection was started at 5:40 p. m. At 8:30 p. m., the urine which was collected through a catheter showed traces of blood. About the same time a chill began, which rapidly reached convulsive violence. The temperature, 102.2 F., at the start of the experiment, rose rapidly to 111.2 F., at 9:20 p. m. Death occurred at this point. During this time 500 c.c. of solution was injected intravenously, and 980 c.c. of urine was passed. The output exceeded the intake by 480 c.c., or 42 c.c. per kilogram of body weight. Nonprotein blood nitrogen at the start of the experiment was 23 mg. per hundred c.c. Just prior to death, it had reached 31.5 mg. per hundred c.c.

The data for other dogs will be given in tabular form.

11. Balcar, J. O.; Sansum, W. D., and Woodyatt, R. T.: Fever and the Water Reserve of the Body, Arch. Int. Med. **23**:116 (July) 1919.

EXPERIMENT 2.—Dog 10, female, weight, 9,725 gm., was injected with a fluid the formula of which was: Sodium chlorid, 88.32 gm., potassium chlorid, 1.98 gm., calcium chlorid (anhydrous), 1.5 gm., hydrochloric acid, 40 c.c., and water, 2,000 c.c.

TABLE 8.—RESULTS OF FORCED DEHYDRATION IN DOG 10*

Time	Temp.	A C. c.	B C. c.	C C. c.	D Mg.
3:00 p. m.	101.4	0	0	0	20
7:45 p. m.	105 8	510	1180	68	36

* In this table and in Tables 9, 10 and 11, column A gives fluid intake at the time stated; B, urinary output; C, dehydration in c.c. per kilogram of body weight; D, nonprotein blood nitrogen in milligrams per hundred c.c. Columns A and B are given as cumulative quantities. The first figure in each column is the normal; the last figure is at the time of death.

EXPERIMENT 3.—Dog 16, male, weight, 12,325 gm., was injected with a dehydration fluid composed of sodium chlorid, 99 gm.; potassium chlorid, 3.30 gm.; calcium chlorid (anhydrous), 2.86 gm.; water, 2,000 c.c.

TABLE 9.—RESULTS OF FORCED DEHYDRATION IN DOG 16*

Time	Temp.	A C. c.	B C. c.	C C. c.	D Mg.
12:00 n.	101.8	0	0	0	30
2:00 a. m.	101.8	200	130	—5.6	30.8
4:00 a. m.	102.2	400	520	9.7	30.8
6:00 a. m.	100.4	450	790	27.6	31.5
8:00 a. m.	99.6	450	835	31.2	32.5
10:00 a. m.	99.6	450	860	33.3	33.4
12:00 a. m.	99 8	450	875	34.6	37.5
2:00 p. m.	101.0	450	880	34 9	43.0
4:00 p. m.	101.6	450	880	34.9	48.0
6:00 p. m.	102.6	450	880	34.9	57.0
6:45 p. m.	103.4	Died			75.0

EXPERIMENT 4.—Dog 20, male, weight, 4,645 gm., was injected with a dehydration fluid composed of 35 per cent. glucose solution of which enough was given to provide 6 gm. of glucose per kilogram of body weight.

TABLE 10.—RESULTS OF FORCED DEHYDRATION IN DOG 20*

Time	Temp.	A C. c.	B C. c.	C C. c.	D Mg.
3:20 p. m.	101.2	0	0	0	28.6
4:10 p. m.	101.4	80	130	10.9	..
7:20 p. m.	100.4	80	233	33.2	30
11:20 p. m.	100.4	80	254	37.8	35.3
3:20 a. m.	101.0	80	273	41.9	46.0
7:20 a. m.	101.4	80	286	44.7	60.0
11:20 a. m.	102.4	80	292	46.0	63.0
1:30 p. m.	103 6	80	295	46.7	92.0

EXPERIMENT 5.—Dog 23, female, weight, 13,520 gm., was injected with a dehydration fluid composed of 35 per cent. glucose solution of which enough was given to provide 6 gm. of glucose per kilogram of body weight.

TABLE 11.—RESULTS OF FORCED DEHYDRATION IN DOG 23*

Time	Temp.	A C. c.	B C. c.	C C. c.	D Mg.
10:30 p. m.	101.2	0	0	0	25
7:00 a. m.	101.0	230	355	9.26	37.5
3:00 p. m.	102.6	230	390	11.85	70
8:00 p. m.	104.0	230	412	13.5	75
10:30 p. m.	105.4	230	416	13 8	86
11:30 p. m.	105.8	230	422	14.2	100

In these five experiments it will be noted that marked rises in concentration of the nonprotein blood nitrogen occurred. Dog 8 showed a rise of 8.5 mg., or 37 per cent., during three hours and forty minutes. Dog 10 showed 16 mg., or 80 per cent. rise, in four hours and forty-five minutes. The other three dogs gave rises of 150 per cent., 212 per cent. and 300 per cent. during eighteen and three-fourths hours, twenty-two and one-half hours and twenty-five hours, respectively; all occurring as a result of water loss. Acidosis, while it might have increased as a result, apparently had little influence as a causal factor. It is also apparent that in the more rapid dehydrations the initial rise was greater than in the other cases, but not so well sustained on account of the early death of the animal and consequently the same heights were not reached.

COMMENT

It seems clear from an experimental standpoint that water deprivation is the most important, if not the sole, factor in the production of the pseudo-uremia of intestinal obstruction. Waste nitrogen increase in the blood is prevented by an assured water supply during obstruction or is produced in the absence of either obstruction or a preexisting nephritis by severe water loss. Renal changes are undoubtedly present, but must result largely from the almost total absence of available water and the high concentration of the toxic waste products in the blood. The diminished urinary output of intestinal obstruction is also undoubtedly traceable to the large intestinal output of water and the resultant dehydration.

Viewed in this light, the condition becomes a pseudo-uremia of thirst rather than of intestinal obstruction; an increase in the rate of protein catabolism where insufficient fluid exists combined with a lack of water as a vehicle for excretion of the toxic split products as they accumulate in the blood. Why protein destruction should occur so much more rapidly in the absence of an ample water supply is, at present, not entirely clear. The answer probably rests in the field of colloidal chemistry. A more or less cursory search of the literature has

failed to throw light on the question, but a tentative explanation may be offered for use until the chemists shall have either confirmed or disproved it:

Proteins exist in vivo as complex nitrogenous bodies of low osmotic pressure. They are loosely combined with small amounts of water; the so-called water of hydration, which is essential to the stability of the molecule. It is also safe to state that protein metabolism, while it may be minimized, can never be entirely eliminated; witness the impossibility of reducing the nonprotein nitrogen of the blood beyond certain low limits, perhaps 15 or 16 milligrams per hundred c.c. by any device of protein free diet, forced fluid intake or other measures. In the presence of a continued elimination of urinary nitrogen, this can mean but one thing; protein disintegration. If fresh water is not forthcoming at frequent intervals, the available water supply of the body is gradually exhausted through the urine, expired moisture and sweat. At this point, an increase in the waste nitrogen of the blood will commence from simple retention because of lack of a vehicle for excretion. It seems probable that repeated small increments of such substances as urea, creatinin and uric acid would cause a rise in the osmotic pressure of the remaining body fluids to that point at which the proteins gave up their water of hydration to the superior force and commenced to break down as a result. The intravenous injection of concentrated salt or glucose solution would not only expedite water loss but would also cause a rapid artificial rise of osmotic pressure in the body fluids. To resume, this breakdown of protein would in turn cause an increased production of waste nitrogen, a further rise in the osmotic pressure of the body fluids and a more widespread attack on the remaining protein. It culminates in a truly vicious circle which gains momentum as it goes and can be broken only by the administration of water. Reference to the experimental records will show that the reaction actually increases in velocity in the later stages as evidenced by the accumulation of waste nitrogen. Although a discussion of nephritis is not within the scope of this paper, it is possible that a similar mechanism may be operative in the production of uremia, once an appreciable retention has occurred.

Turning momentarily from the subject of protein disintegration to that of the excretion of the waste products during intestinal obstruction, it is found that these, together with the major portion of the body's fluid output, pass into the intestine above the obstruction. If, at any time, water loss causes them to assume an increased concentration in the blood, renewed aqueous intake will cause a fresh outpouring of fluid and a washing out of the accumulation of waste. While no search has been made for intermediate products of protein destruction,

such as proteoses, they must be formed at some stage of the catabolic process, and no reason is apparent why they should not accompany the simpler waste products in their passage into the intestine. Appropriate chemical methods have already demonstrated the presence of such substances in the fluid excreta. These, we are inclined to think, constitute the duodenal toxins found by other workers and are not formed in situ by the cells of the intestinal mucosa, but excreted by them from the blood stream into the intestine. There is no definite proof of the existence of toxins formed in situ, and even if present, it is difficult to believe they could be absorbed against the outpouring current.

To renew the consideration of protein destruction in dehydration, this phenomenon may be traced through various apparently unrelated conditions and is of sufficient importance to warrant a digression from the subject of intestinal obstruction. First in importance is the question of fever and the mechanism whereby it is produced. Vaughan [12] has caused fever by the injection of small quantities of protein. Balcar, Sansum and Woodyatt found it to result from severe dehydration which they believed to be the determining factor. It is now apparent that water loss causes the destruction of protein, and it seems probable that the two theories may be unified and that dehydration through the resulting protein disintegration causes fever after the theory of Vaughan. This must be aggravated by the absence of water with its high specific heat, and the body in consequence lacks an agent for absorption and transportation of the excess calories to the surface where they may be radiated, as explained by the Chicago workers.

There is available for discussion what is undoubtedly a clinical example of fever following dehydration; namely, heat stroke or thermic fever. This occurs during the torrid spells of summer or in those working under conditions of high artificial heat as found in engine rooms or the like. Actual heat stroke is usually preceded by profuse and prolonged sweating. The victim is then seized by a chill, which may result in high fever, temperatures of 107 or 108 F. being frequently recorded. Gradwohl and Schisler [13] have noted that in heat stroke tremendous rises occur in the urea nitrogen of the blood. These facts when considered together make it seem probable that the condition is but an example of a general physiologic response to water loss; the disintegration of protein with the production of fever when a

12. Vaughan, V. C.; Vaughan, V. C. Jr., and Vaughan, J. W.: Protein Split Products in Relation to Immunity and Disease, Philadelphia, Lea and Febiger, 1913, pp. 373-415.

13. Gradwohl, R. B. H., and Schisler, E.: A Study of Thermic Fever, Am. J. M. Sc. **154**:407 (Sept.) 1917.

sufficient velocity of reaction is attained. Woolley[14] has, indeed, suggested an explanation identical with that mentioned above in an effort to make clear the pathology of heat stroke. In this connection, it is interesting to note that fever in intestinal obstruction, usually considered diagnostic of peritonitis or other complications, may be of aseptic origin. If, at any time, the accompanying water loss causes the body protein to break down with sufficient rapidity, fever will result in the absence of infection.

Still other conditions, for instance peritonitis and pneumonia, occasionally exhibit definite rises in concentration of the nonprotein blood nitrogen and the cause for them has in the past been most uncertain. They are usually, however, associated in both conditions with unfavorable cases and carry with them a grave prognosis. In peritonitis, the patients are apt to be those who vomit frequently and take water poorly. In both diseases, the pulse may be so rapid and the circulation so inefficient as to distribute the fluids at hand very imperfectly. Studies in cardiac efficiency by various workers have shown that a rapid heart beat gives an inefficient circulation and that when cardiac edema exists a slowing of the pulse increases circulatory efficiency and thereby aids in absorption of the fluid deposit. Conversely, an increase in the heart rate may permit more fluid to leave the vessels and gravitate to the dependent portions of the body with production of a regional dehydration when no general dehydration exists. Hence, the circulatory condition may offer one cause for water shortage.

If we may use for our purposes a portion of the theory of Balcar, Sansum and Woodyatt, another possibility becomes apparent. These workers suggest that the body water exists in two forms, first free and uncombined, in which state it is available for purposes of heat absorption and transportation; second, in colloidal combination with the proteins, glycogen, etc., which destroys its ability to regulate heat. They think it possible that infection so poisons these hydrophilic colloids as to increase their hydration capacity, thereby leaving a scarcity of free water, and point to the water retention of pneumonia, with its suddenly enhanced excretion as sweat and urine at the crisis, for support. If this theory approximates the truth, and the necessary water of hydration for the proteins were to be largely increased, some portions might be unable to secure the necessary fluid. In such a case, it might be expected that they would commence to disintegrate, perhaps with the production of fever, certainly with increased formation of nitrogenous waste. Any or all of the above mentioned factors may influence the formation of

14. Woolley: Cited by McKenzie, Pierce, and LeCount, E. R.: Heat Stroke, J. A. M. A. **71**:260 (July 27) 1918.

excess blood nitrogen in the two diseases under discussion, and the remedy is water although various difficulties, both mechanical and chemical, may interfere with the administration.

Again Minsk and Sauer [15] report that the nonprotein nitrogen of the blood in atrophic infants rises at times, and if over 30 milligrams per hundred c. c. carries with it an unfavorable prognosis. Once more a nonnephritic rise of the blood nitrogen is found and one which probably results from a disturbance of water balance.

The list of conditions in which water loss may cause protein destruction, accumulations of waste nitrogen in the blood and at times fever will doubtless be much enlarged by future observers. In this article have been included a few probable examples to illustrate the possibilities of the situation.

CONCLUSIONS

1. The rise in concentration of nonprotein blood nitrogen observed in intestinal obstruction is due, not to that condition per se, but to the accompanying water loss.

2. An increase of blood nitrogen in intestinal obstruction may be prevented by the administration of sufficient water.

3. An increase of blood nitrogen may be experimentally produced in the absence of intestinal obstruction or of a preexisting nephritis by the adoption of any measure calculated to produce severe thirst.

4. Death from intestinal obstruction is, in the absence of complications, due to toxemia from the protein disintegration which occurs after severe water loss. It is the most common clinical example of death from thirst.

5. The toxic nitrogenous residue is excreted from the blood stream by the intestinal mucosa into the intestine where it may exist in higher concentration than in the blood. If not drained out, on relief of the obstruction, the material may be reabsorbed by the lower bowel and colon, causing an increase of the already existing toxemia.

6. Fever in intestinal obstruction may be of aseptic origin and indicate nothing more than the protein disintegration occurring in severe dehydration.

7. An increase in the noncoagulable blood nitrogen of diverse conditions, as heat stroke, peritonitis, pneumonia and the atrophy of infancy, depends on low water reserve and in the absence of nephritis may be used as a reliable guide for the administration of water.

8. The two chief theories of fever, the protein theory of Vaughan and the dehydration theory of Balcar, Sansum and Woodyatt, may be unified by showing that the latter depends on the former.

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15. Minsk, L. D., and Sauer, L.W.: Nonprotein Nitrogen of the Blood in Atrophic Infants, Am. J. Dis. Child. **13**:397 (May) 1917.

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